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Newsletter

Hawaiian Botanical Society

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Contents

VOLUME 14 NUMBER 1 FEBRUARY 1975

THE HAWAII IBP PROJECT
by Sheila Conant 3

CONSERVATION COLUMN--PROPOSALS IN THE EIGHTH STATE LEGISLATURE
by Ruth Gay 11

DANGEROUS AND ENDANGERED SPECIES: A POLITICAL UPDATE ON NATIVE ECOSYSTEMS
by Catherine Craine 13

BRIEF REPORTS AND NOTES

SOCIETY BUSINESS...2; EDITORIAL...18; CALENDAR OF UPCOMING BUSINESS...19; NEW MEMBERS...19.

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE REGULAR MEETING OF DECEMBER 2, 1974

The meeting was called to order by the president, Dr. Theobald, at 7:35 p.m. Both the secretary and the treasurer were absent. Substituting for the secretary, Ms. Mary James read the minutes of the previous meeting and the secretary's annual report. The minutes were approved as corrected. There were 20 members and 10 guests in attendance.

For the Conservation Committee, Ms. Ruth Gay reported that the portion of a bill which would weaken the Federal Endangered Species Act of 1973 had been deleted. She also announced that Mr. Harry at the Hawaii Volcanoes National Park wanted input for the draft concerning an approval of Hawaiian homesites in the Kalapana extension. She said that the Committee would work on this, but would welcome any help. The deadline was February 1.

The following were elected for 1975---President: Dr. Derral Herbst; Vice President: Dr. Sheila Conant; Secretary: Ms. Jean Maka; Treasurer: Mr. Paul Yamanaka; Directors: Dr. William Theobald, Dr. Charles Lamoureux.

A proposal for a travel grant to the 55th Annual Meeting of the Western Society of Naturalists in Vancouver for a graduate student, Mr. Bruce Allender, was read by the president. After favorable discussion, it was moved and seconded that the Trustees of the Marie Neal Fund be asked to grant this. However, it was suggested that the Society think more about the matter before setting a precedent. The motion was tabled with no opposition.

The vice president, Dr. Herbst, introduced the speaker, outgoing president, Dr. William Theobald, who discussed "A new manual to the Hawaiian Flora."

A plant display of bananas and citrus by Dr. Warner was followed by special Christmas refreshments by Dr. Kefford.

Jean Maka, Secretary

MINUTES OF THE REGULAR MEETING OF JANUARY 6, 1975

The meeting was called to order by the president, Dr. Herbst, at 7:30 p.m. The secretary read the minutes of the previous regular meeting. They were approved as read. There were 21 members and 13 guests in attendance.

The treasurer gave the report for January.

Dr. Herbst introduced the new membership chairman, Ms. Lani Stemmermann, and the new *Newsletter* editor, Mr. Bill Hoe.

Dr. Warner announced that the first plant donation was to be in March.

Mr. Ron Hurov reported receiving letters expressing interest in natural products. Mr. Oscar Kirsch showed those present his two awards for outstanding work in conservation.

The vice president introduced the speaker, Mr. Glen Spence, who talked on "The Natural History and Conservation of the Dry Forest of Lanai."

Mr. Kirsch showed the group some unique African orchids.

Refreshments were served by Ms. Bea Krauss.

Jean Maka, Secretary

THE HAWAII IBP PROJECT

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PART I. SCOPE AND OBJECTIVES

The concept of an "International Biological Program" was suggested by the International Council of Scientific Unions, the International Union for Biological Sciences and other international organizations, and planning for the program began in 1961. It was envisaged as a potentially world-wide, integrated effort to achieve an understanding of ecosystem function that would benefit both efficient, non-destructive use of the environment by man, as well as management, conservation and preservation of ecosystems and natural resources. This objective was to be implemented by ecological research in well-defined ecosystems (i.e., biomes: grasslands, deserts, deciduous forests, etc.) in participating countries throughtout the world. Although IBP Projects were established in many countries, they received the most financial support in the United States through the National Science Foundation.

The Hawaii subprogram of the IBP, now known formally as the Island Ecosystems Integrated Research Program, was first funded in 1970 after the second draft of the research proposal was accepted and funded by the National Science Foundation. The proposal, authored by Drs. A. J. Berger, J. L. Gressitt and D. Mueller-Dombois, outlined a program of research aimed at examining the differences between insular and continental ecosystems, to be accomplished primarily by a thorough interpretation of ecosystem structure and dynamics in Hawaii.

In defining their objectives, Hawaii IBP Project participants decided to focus on evolution and ecosystem stability. Hawaii's unique biota contains numerous groups of organisms that show a high percentage of endemicity, extraordinary adaptive radiation, and, in many cases, atypical or unique specializations. Ecosystem stability is a significant problem in any insular environment, and is perhaps more serious in this most isolated of all island groups. Disturbance of ecosystems by habitat alteration and introduction of exotic biota has had serious consequences in Hawaii. Numerous endemic organisms, including insects, birds and plants have become extinct, and Hawaii leads the world in numbers of rare and endangered species. Indeed, some unique Hawaiian ecosystems such as lowland dry forest have almost completely disappeared, while others, such as the mamane-naio (*Sophora chrysophylla-Myoporum sandwicense*) forest on Mauna Kea are certainly endangered. To examine some of these problems more closely, IBP participants developed four general objectives:

1. To determine why some organisms have undergone extensive speciation, while some of the most successful have not.

The genus *Cyrtandra* (Gesneriaceae) provides an excellent opportunity to examine the factors influencing speciation. On the island of Oahu there are well over 100 endemic species in this genus, while on Hawaii there are less than 20 species endemic to that island. Many of the species found on Oahu are believed to have more restricted distributions than the species found on Hawaii. Naturally, biologists are interested in finding out why these dramatic differences in species number and distributions exist between the two islands. Island age must certainly be important, but undoubtedly many rather specific environmental factors have influenced the adaptive radiation we observe in this genus, and defining these factors is a challenge to biologists.

Similar examples can be found in other groups of endemic plants and animals. What are the factors that influence these evolutionary processes? While evolutionary biologists and ecologists in the Hawaii IBP Project cannot expect to answer fully this question, many interesting discoveries are being made as data are collected.

2. To determine rates of speciation and the factors influencing these rates.

Geologically, Hawaii is one of the earth's youngest land groups, in fact, it is still growing through gradual but constant volcanic activity. However, during its short life span (1 to 11 million years for the youngest and oldest islands), a great variation of habitats and communities developed, and approximately 1400 species of flowering plants, 6000 kinds of insects, 1000 terrestrial molluscs, and 70 different birds have evolved from a surprisingly small number of colonizers (270 plants, 250 insects, 24 molluscs, 15 birds). Examples of spectacular adaptive radiation are numerous in the biota. For example, believed to have arisen from one species are over 200 plant species in the genus *Cyrtandra*, over 600 kinds of Drosophilid flies, and 22 different species and 23 subspecies of honeycreepers (Drepanididae). All this has taken place within approximately the last 10 million years of the earth's history.

There is no question that factors such as the diversity of climates, terrain, age of substrate and the geographic and ecological isolation associated with these factors are important influences on the rates and directions of evolution of the Hawaiian biota. Specifically how these and other influences are related has been the focal point for a number of research projects in the IBP Project in Hawaii.

3. To determine the nature of ecosystem stability and fragility.

Insular ecosystems are notably fragile in comparison to continental ecosystems. Because the Hawaiian biota evolved in such an isolated situation, it is particularly susceptible to the kinds of disturbance associated with the arrival of man, who has brought with him a wide variety of plants and animals for food, recreation, and aesthetic enjoyment. Many of these exotic organisms have flourished in Hawaii because the environment is hospitable to them. They are not kept in check by the competitors, predators and diseases found in their own native ecosystems. At the same time the native organisms found in Hawaii often cannot compete with the pressures imposed by exotic organisms. For example, the invasion and consumption of Hawaiian forests by introduced ungulates such as pigs, goats, sheep and cattle clears the way for exotic plants. Exotics are often resistant to grazing animals because they possess adaptations (thorns, unpalatability, etc.) not found in the native flora, because the latter evolved in the absence of grazing mammals. Similarly, the native avifauna is apparently highly susceptible to diseases unintentionally brought in with introduced birds. Just as the Hawaiian people succumbed in large numbers to diseases of Western man, so populations of Hawaiian birds are believed to have suffered greatly with the introduction of avian malaria and bird pox.

While the fragility of some native organisms is easily explained in terms of susceptibility to disease, grazing pressures, etc., factors influencing the decline or changes in many organism groups are poorly known. This is due, in large part, to a lack of information about the biology of both native organisms themselves, and the organisms that have been introduced by man.

It is obvious that some ecosystems and organisms are relatively resistent to change and the pressures of introduced biota, while others are extremely susceptible to the same environmental factors. If IBP participants are able to reach an understanding of these phenomena, they may be able to establish guidelines for ecosystem management in the future.

4. To develop models relating the variables contributing to stability and diversity in Hawaiian ecosystems.

One of the most important accomplishments of modern ecological research is the development of models that can be used to predict the outcome of habitat manipulation (natural or artificial). This is usually the final step in a program of research. Data on a wide variety of organisms and environmental parameters are gathered over time by numerous investigators. After the data have been catalogued, they can be examined and analyzed to see what kinds of relationships exist among ecosystem components, and what functions these relationships may have in maintaining a stable ecosystem. For example, studies of bird populations in a wide variety of habitats may be correlated with vegetation ecology to determine the nature of optimum habitat for different species of birds. This could be particularly important in the management of lands for preservation of endangered species.

Comparative studies of plant growth and dynamics in grazed and ungrazed or logged and unlogged forests may provide guidelines for efficient land management practices relating to silviculture and cattle ranching. Recently completed studies of the effects of feral goats and pigs on plant growth and regeneration and invasion of exotic plants have been an important influence in the Hawaii Volcanoes National Park's decision to eradicate goats from the park in order to let the vegetation recover, thus enhancing the quality of the habitat for native organisms, especially the rare ones.

While the four general objectives of the Hawaii IBP Project served as guidelines for planning an overall research strategy, specific objectives were defined to provide a framework in which to present the information gathered during the life of the project. These are to explain:

1. Spatial distribution of island biota along an altitudinal gradient
2. Temporal relations of ecosystem flux (growth, population dynamics, reproduction, etc.)
3. Community structure and niche differentiation
4. Genetic variation within island species

These objectives have been selected as the four basic themes for presentation of results in the Hawaii IBP synthesis volume, which is in preparation for publication in 1976. In this volume the editors, several IBP participants, will use the information presented in each specific theme section to address themselves to the Project's general objectives.

In addition to the abovementioned long-term scientific objectives, the Hawaii IBP Project formulated several practical objectives:

1. To provide information for wildland management in Hawaii
2. To develop knowledge useful for the conservation of biological resources in Hawaii and other island ecosystems
3. To assist in education, specifically by engaging graduate students in team research of Hawaiian ecosystems

PART II. RESEARCH ACTIVITIES

The majority of field research was conducted on the island of Hawaii in the ecosystems found principally on two major transects that were laid out in the initial stages of the project. The Bishop Estate invited IBP participants to conduct studies in a relatively undisturbed montaine rain forest at the upper end of one of the two major transects. This proved to be such a rich area that a 200 acre portion of it was adopted as an intensive study site. Several investigators also worked at other sites on the island of Hawaii and on other islands when their research required data collection from additional sites. The scope of the Hawaii IBP Project is so large that only a few of the research projects will be described in this article.

Because most of the field work was done on Hawaii, while most of the investigators resided on Oahu, a field station with living quarters and laboratory facilities was established in Hawaii Volcanoes National Park. At the same time several vehicles were maintained on Hawaii for field work.

Two well-equipped meteorological stations and several substations were established and serviced weekly to provide data on temperature, rainfall, relative humidity, etc.

Periodic soil sampling was carried out at most of the study sites on the transect and in the Kilauea Forest Reserve. Some of the samples were collected to gather data on soil moisture, and the remainder were put into Burlese funnels, which are used to extract arthropods from the soil.

Working with aerial photographs provided by the State Survey Department, Drs. Mueller-Dombois and Fosberg developed vegetation maps for all of Hawaii Volcanoes National Park. This work was done and the maps printed under the auspices of the Cooperative National Park Resources Studies Unit (Mueller-Dombois and Fosberg 1974). The maps will be a valuable tool for anyone conducting research in the park, inasmuch as they are the most complete and extensive collection of vegetation maps available based on aerial photographs of the Hawaii Volcanoes National Park and immediately adjacent areas.

The success of the vegetation mapping project stimulated Dr. Mueller-Dombois to contract John I. Kjargaard to take aerial photographs of the Kilauea Forest Reserve intensive study site. These photographs can be used to construct vegetation maps and are detailed enough to permit identification of individual trees.

The family Drosophilidae (vinegar flies) in Hawaii is represented by over 600 species in the genus *Drosophila*, and all are presumed to have evolved from a single ancestor. Dr. Hampton Carson, his co-workers and students have taken advantage of this spectacular group to study genetic variation and genecology (Paik and Sung 1973). Studies of similar pheonomena in ohia are being conducted by Carolyn Corn and William Heisey (1973) while studies of tree ferns (Lloyd 1974) have been completed.

The discovery of lava tubes as unique, self-contained ecosystems was made by Dr. Frank Howarth of the B. P. Bishop Museum, Department of Entomology (Howarth 1971). This unusual habitat is energetically based on the presence of plant roots that penetrate and continue to grow into lava tubes. Some truly remarkable cave-adapted arthropods have been found, and it is anticipated that others will be discovered in time. Wayne and Betsy Gagne and Dr. Howarth found parts of the skeletons of two new species of extinct flightless birds, a rail and an ibis, in a lava tube in Waihoi Valley on Maui. This discovery was certainly an unexpected one in the field of ornithology, and further demonstrates that lava tube ecosystems are one of the most exciting finds to arise during IBP research in Hawaii.

Studies of the organization and dynamics of plant communities on IBP study sites have been quite productive. The Kilauea Forest Reserve intensive site had been the focus of two studies of community structure by Jean Maka (1973) and Ranjit Cooray (1974), and various plant communities on the Mauna Loa transect have been described by a number of workers (Mueller-Dombois 1970, 1972).

Koa has been the subject of several ecological studies emphasizing growth and reproduction (Spatz 1973; Spatz and Mueller-Dombois 1973). It is anticipated that the results of these studies will be of importance in koa silviculture and the management of native forests.

Charles van Riper (1975) and Drs. Charles Lamoureux (1973) and John Porter (1973) have been involved in studies of phenological (time related) events in the plant community. This is an especially interesting problem in tropical and subtropical environments because of the lack of seasonality. Hopefully the results of these projects will point out some of the environmental factors that influence the nature and timing of flowering, fruiting, leaf fall, foliage flushing and lateral growth. These pheonomena undoubtedly have considerable influence on populations of birds and insects, and so the results of phenological studies can be applied to an understanding of other ecological processes.

Plant succession has been examined in several different projects. In Hawaii the development of plant communities on new lava flows is an obvious and interesting process. Drs. G. Smathers and D. Mueller-Dombois (1972) reported the results of a nine-year study of plant succession on a new lava flow near Kilauea Iki on Hawaii.

Secondary succession occurring in the aftermath of disturbance by feral mammals has been the subject of several projects. One of the more significant discoveries made in this line of inquiry is that digging by feral pigs facilitates the invasion of exotic plants in grassland communities (Spatz and Mueller-Dombois 1972).

One of the more recent studies to be undertaken by plant ecologists in the Hawaii IBP Project focuses on the "Ohia Dieback" problem. This has been discussed in detailin a research proposal written by Dr. Mueller-Dombois (1974) in which he has pointed out that the precise nature of ohia dieback is far from completely understood, and that a thorough study of community structure and dynamics, especially reproductive strategies and soil-water relations, is imperative before management policies for dieback areas are finalized.

The entomologists in the Hawaii IBP Project have one of the most complex tasks of any group of principal investigators due to the sheer magnitude of the insect fauna. In addition, entomologists are also charged with investigating arthropods other than insects. Identification of specimens often presents difficulties and descriptions of community structure and ecological niches can be quite complicated. Nevertheless, descriptions of insect communities at several levels will be completed shortly, and many special problems are being investigated.

Knowledge of the evolution and ecology of Hawaiian birds is very scant, and its acquisition is of immediate importance because so many of Hawaii's native birds are extinct, while many of the remaining species are rare and endangered. Some of the problems encountered in the preservation and protection of

Hawaiian birds are habitat alteration, competition from exotic birds, and susceptibility of native birds to diseases brought in with foreign birds.

A number of ornithologists and their students are conducting a variety of studies of both native and introduced birds. Anatomical studies are especially important to reaching an understanding of the evolution of Hawaiian birds, although ecological data are also significant. The Hawaiian honeycreeper family (Drepanididae) is one of the best examples among animals of adaptive radiation. Among the honeycreepers there is a tremendous range of bill types, plumage colors, habitat preferences and feeding behaviors. This makes the family ideal for comparative evolutionary and ecological research, and the IBP Project has been instrumental in facilitating research projects on anatomy, physiology, behavior and ecology.

An extensive survey of population dynamics of small mammals has been conducted by Dr. P. Q. Tomich with the assistance of James D. Jacobi. Three species of rats (*Rattus exulans, R. norvegicus, R. rattus*), the house mouse (*Mus musculus*), the small Indian mongoose (*Herpestes auropunctatus*) and an occasional house cat (*Felus domesticus*) were included in this study. Eighteen transects were established, and trap lines were run periodically. Data were gathered on size, weight, stomach contents, ectoparasites and population densities, as well as movements and age of marked and released animals.

The effects of feral goats on vegetation are being examined in several ways. Exclosure studies have been the most extensive and revealing. One of the more interesting results of exclosure studies was the discovery of a new plant species in the pea family (Leguminosae) *Canavalia kauensis* (St. John 1972), in the Kukalauula area. Apparently the grazing pressure of goats had been so great that, although viable seeds of this plant had been on the ground, any seedlings that arose were immediately eaten by goats. It was only after an exclosure had been built that germinants of this plant were able to grow.

The Hawaii Volcanoes National Park's program of goat eradication is necessarily a slow and arduous task, but well worth the time and effort involved. In those plantcommunities from which goats have been nearly or totally removed, the vegetation has realized remarkable regenerative potential in less than two years (Mueller-Dombois and Spatz 1972).

Feral pig ecology has been investigated along the same lines as feral goat ecology. The principal difference between the effects of these two animals is that the goat is more important in drier ecosystems, while the pig has a significant impact on wet forest ecosystems. Pigs are frequently found in dry habitats, but goats never invade rain forests.

The fact that feral pig digging facilitates the invasion of exotic plants in grassland communities has been mentioned. Pig damage to vegetation has been investigated in the Kilauea Forest Reserve where their effects are assessed by exclosure studies and observations are made on the mortality of koa seedlings and tree ferns, both favored foods of the feral pig. Although studies have not been completed, it seems evident that feral pigs have a deleterious effect on koa regeneration, and the growth of plants on the forest floor.

At present, data collection for field studies has been completed and data analysis and writing are underway. In fact, more than 50 technical reports have been issued and it is anticipated that many more will be written in the coming months.

Dr. Kent Bridges, assistant director of the project, has been responsible for assisting most project participants with data analysis and program designs for data processing directed at storage, integration, comparison and standardization of data. Under his direction there has been a coordinated effort to catalog and store programs for data analysis on computer tape, as well as a large part of the data collected by project participants.

Dr. Bridges has been assisted by a computer programmer, Ms. Virginia Carey, and a key punch operator. Ms. Carey has been responsible for the compilation of species lists for project research. Dr. Bridges and Ms. Carey (1973, 1974) have compiled the data from IBP meteorological stations to make it available to researchers as supplementary data. A large number of analysis programs are underway at present, and many more must be undertaken as the project draws to a close.

The coordination of research activities, financial matters, production of technical reports, etc. have been handled by Ms. Lynnette Araki, assisted by Ms. Barbara Myers, and by Ms. Carol Higa of the Entomology Department at the B. P. Bishop Museum. Ms. Araki and Ms. Myers, although employed by the Bishop Museum, carry on their work in the office of the Hawaii IBP Project in the Department of Botany at the University of Hawaii.

Integration of field research, maintenance of vehicles, living quarters, meteorological stations, and assistance with field data collection have been some of the responsibilities of the field station site manager on Hawaii. Mr. James D. Jacobi has held this position for a considerable period of time, but several other site managers have been employed at various times during the project.

The preparation of a synthesis volume, which will present a synthesis of the methods and results of research conducted by all of the project's principal investigators, was begun in late 1974. In addition to discussions of ecosystem structure and evolution, the two principal areas of research, the synthesis volume will include a section on the application of results to land management and conservation of biological resources in island ecosystems.

As any research program draws to a close it always becomes clear that some of the questions investigated are not fully answered, and also that the research itself has raised new questions; this is certainly true of the Hawaii IBP Project. It is natural for one research project to lead into others, and the Hawaii IBP Project has acted as a stimulus for many of its principal investigators to take on new problems for future research.

The establishment of new projects will provide means for the continuation of many lines of inquiry begun during the IBP Project. Two of these new projects will, in fact, provide means for the direct continuation of some studies.

The first of these to be established is the National Park Service Cooperative Resources Studies Unit, under the direction of Dr. Maxwell S. Doty. He will work in cooperation with the National Park Service in conducting research in Hawaii Volcanoes National Park and Haleakala National Park, and training graduate students in resource management. A field station, the Hawaii Field Research Center, is now in operation and provides facilities for on-site field work in Hawaii Volcanoes National Park.

Another project, MAB 7 (Man and the Biosphere) is now in the planning stages. This project will have a wider scope than the IBP Project, and will include anthropologists, sociologists, and economists, and other researchers whose interests are directly related to human projects. Thus these new programs will not only continue much of the valuable research initiated through the IBP, but also enlarge its scope and broaden its application.

ACKNOWLEDGEMENTS

I thank Dr. Dieter Mueller-Dombois for his helpful comments on the manuscript.

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CONSERVATION COLUMN

PROPOSALS IN THE EIGHTH STATE LEGISLATURE

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Senate Bills 195 and 1665 complement the Federal Endangered Species Act of 1973 by proposing controls on intrastate traffic to supplement the interstate control provided by the federal law. SB 195 prohibits the importation, sale or possession with intent to sell any endangered species or part thereof, except under permit from the Department of Land and Natural Resources. The definition of endangered species in this bill does not include plants. Generally favorable testimony on SB 195 was received on February 25 by the Senate Committee on Ecology, Environment and Recreation. SB 1665 (identical to HB 1867) calls for the replacement of part II, Chapter 191 of the Hawaii Revised Statutes, relating to the conservation programs of the Department of Land and Natural Resources. The provisions of this bill extend previous legislation to include protection and management of endangered plants. The DLNR would enforce the prohibition of export, possession, processing or sale of endangered species and would issue permits of exception. The bill substitutes the term "wild" for "indigenous" in referring to endangered species. The following provisions in the current revision of Chapter 191 would be deleted under SB 1665:

that action be taken to insure that activities by state agencies do not jeopardize the continued existence of endangered species;

that priority be given to those endangered species and their ecosystems whose extinction within the state would imperial or terminate their existence in the world;

that the DLNR keep an updated list of endangered species;

that the DLNR conduct research on indigenous biota and endangered species and their associated ecosystems; and

that the DLNR coordinate its work on endangered species with the Natural Areas Reserve Commission and the Animal Species Advisory Commission.

The first public hearing on this measure was held on March 6.

Senate Bill 1518 makes an appropriation of $25,000 or so much thereof as may be necessary for the protection and preservation of endangered species of flora and fauna in the County of Hawaii.

Senate Resolution 244, Senate Concurrent Resolution 63 and *Senate Bill 970* relate to the protection of Hawaii's native ecosystems on Mauna Kea. The resolutions direct the Division of Fish and Game to construct two fences from 7000 to 11,000 feet on the west side and east side of the mountain; to move all feral sheep, mouflon sheep and goats from the south to the north side of these fences; to keep the southern half of the mountain free of these animals; to solicit public advice during this program; and to report progress before the next regular legislative session. SB 970 makes an appropriation of $50,000 or so much thereof as may be necessary for the above fencing scheme. The majority of testimony given at the Senate Committee on Ecology, Environment and Recreation on February 25 was in support of these measures. Biota on Mauna Kea that are (or in the case of plants will be) on the Federal Rare and Endangered Species List include one mammal species, six bird species and fifteen plant taxa.

House Bill 489 proposes changes in the Animal Species Advisory Commission's responsibilities. The Commission is now mandated under Chapter 187, Hawaii Revised Statutes to advise the Division of Fish and Game on every proposal for the deliberate introduction of a species of animal by the Department of Land and Natural Resources into any habitat within the State, and on any matter affecting fishing or hunting, and fish and wildlife conservation. The general proposals of HB 489 are reviewed in the following testimony presented by the Society to a joint hearing of the House Committee on Environmental Protection and Water, Land Use Development and Hawaiian Homes on March 6:

"The Hawaiian Botanical Society opposes HB 489 which would allow the Department of Land and Natural Resources to introduce animals into any area of the state without review by the Animal Species Advisory Commission, and to subsequently liberate such introduced animals without a required public hearing. Under this proposed legislation, the immediate introduction of axis deer onto the Island of Hawaii would become possible, and the deer could then be released without prior public response. In view of the potentially destructive impact of axis deer upon ranches, sugar plantations, truck farms, other agricultural and horticultural crops and native vegetation, the Hawaiian Botanical Society has long opposed the introduction of axis deer onto Hawaii. We thus submit this testimony against a measure which would remove essential review of plans to introduce and liberate such animals in new habitats."

Senate Bill 1372 provides for the establishment of an Arborist Advisory Committee on each county to be appointed by the mayor. Each committee would develop regulations, ordinances and procedures to safeguard exceptional trees from destruction due to improper land development. "Exceptional trees" is defined as "a tree or stand or grove of trees with historic or cultural value, or which by reason of its age, rarity, location, size, esthetic quality or endemic status has been designated by the county committee as worthy of preservation. Testimony heard by the Senate Committee on Ecology, Environment and Recreation on March 6 was in support of this bill. The Hawaiian Botanical Society submitted testimony pertaining to the terminology within the bill and in general support of this effort to protect a valuable scientific resource.

Senate Resolution 240 and *Senate Concurrent Resolution 59* direct the Department of Agriculture to gather and compile material on the biocontrol of *Clidemia hirta*, including the funding requirement for continued or renewed control measures for this weed.

DANGEROUS AND ENDANGERED SPECIES: A POLITICAL UPDATE ON NATIVE ECOSYSTEMS

Catherine Craine
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University of Hawaii - Manoa

An ecosystem is a unit that includes all of the organisms in a given area, recognizing that they are inseparably interrelated and interacting with their nonliving environment and with each other. A native ecosystem is one that evolved in the area that it occupies so that is it uniquely adapted to that place.

The existence of native Hawaiian plants, indispensible to native ecosystems, is said to be threatened by grazing and trampling by game animals introduced to Hawaii. These animals are managed by the State Division of Fish and Game for hunting. Native plants evolved tolerances to lava flows, volcanic ash fallout, sulfur fumes, saltspray-laden trade winds, tidal waves, poor soil---the environmental demands of the Hawaiian Islands. However, during their evolution there were no large grazing animals here, and these plants did not evolve the defenses against herbivore browsing and trampling that are characteristic of continental plants. This is one reason why native plants are favored foods of introduced browsing animals. Native plants are quick to recolonize an area after a lava flow, but not to withstand the continued grazing pressure of goats, sheep or deer. Plants have been introduced to Hawaii which are native to areas where the pressure of herbivores has forced them by adaptation, to become grazer-tolerant. Thus the native Hawaiian plants are at a double disadvantage. Plant ecologists and others have said that for these reasons, if the native plants are to survive we must have no grazing animals. And, if the native plants are lost, if they decline and die, then the native animals associated with them will go too--we will lose our native ecosystems.

Many, perhaps the majority of the species that survived and adapted to the Hawaiian environment are already extinct---lost to the world forever. An example, given by the Degeners in a 1969 Star Bulletin editorial entitled "Hawaii's Vanishing Native Plants," concerns mokihana and alani. Of 70 endemic species of mokihana and its close relative alani, 29 have become extinct in the last 200 years. From the birds, the Honeycreeper family provides another example of the loss of species---of 39 endemic species and subspecies known, 14 are extinct and 14 are on the rare and endangered list.

In a November 1969 Honolulu Advertiser article Margaret Titcomb, Bishop

Museum librarian noted that hunting is a pastime that requires many acres of land for food as well as for cover so that hunters can enjoy the sport of stalking their quarry. "Hunters make up about one percent of our population. Some of us think that they are asking a great deal too much of the rest of us," she wrote.

Hunters feel that, on the contrary, they are using land that is wasted---being put to no good use. Hunting is thought of as a healthy, all-American outdoor recreation, an important sport in terms of money and tradition.

In 1949 the Board of Commissioners of Agriculture and Forestry began consideration of a proposed plan to introduce axis deer to the Island of Hawaii. The Board approved a 5-year game development and management program in May 1950 which would have included the introduction of axis deer to the Mauna Loa-Mauna Kea saddle areas. Many letters in opposition were received. The Hawaiian Botanical Society sent a resolution protesting the proposed axis-deer introduction. In the face of controversy, the Board deferred action on the matter.

In 1957 a three-and-a-half year study on the ecology of axis deer was begun by William Graf of San Jose State College and Lyman Nichols of the Division of Fish and Game. Their conclusions, published in the Journal of the Bombay Natural History Society, indicated that the introduction of axis deer to Hawaii would not be harmful.

In 1961, Act 132, Session Laws of Hawaii, transferred the fish and game authority to the Department of Land and Natural Resources (DLNR). At the second State Legislature, in 1963, $3978 was appropriated for "Mauna Kea, Mauna Loa Game Management. Mammal introduction. Game managment area Hawaii." The DLNR considered the introduction of axis deer to the Big Island at the January 1964 board meeting and unanimously voted to instruct the Division of Fish and Game to capture deer and ship them to Hawaii to a 300 acre holding pen on Mauna Kea.

In March 1964, a Big Island cattle ranching corporation, W. H. Greenwell, Ltd. filed for an injunction against the DLNR and all involved in the proposed introduction. Cattle ranchers were opposed on the grounds that the deer would be competition for food, would bring in and spread cattle diseases, and that deer could not be kept out of cattle ranges by fencing. The Circuit Court issued an order temporarily restraining the release of axis deer on the Big Island. The State filed a motion to dismiss the order. In March 1965, the case was tried and the court found in favor of Greenwell---permanently enjoining and restraining the release of axis deer on the Big Island. The State appealed the matter before the State Supreme Court. In 1968, the State Supreme Court reversed the decision of the Circuit Court and the way was again clear for the introduction.

The Division of Fish and Game published a report detailing their answers to the arguments against the introduction. They said, "Axis deer can be adequately controlled and will materially benefit the people of the Big Island and the State as a whole." It was thought that the axis deer would eventually provide a replacement for such 'lower quality' feral animals as goats, pigs, and sheep which are less attractive to sportsmen. The deer were all set to go in the fall of 1969 when Governor Burns halted the first shipment after the Committee on Preservation of Scientific Areas had urged further study. In November 1969, a delegation of University of Hawaii students majoring in biology, zoology, botany, entomology and general science visited Governor Burns, bringing with them a petition signed by 1070 students. The petition asked that further study be made of the deer's relationship to the native flora and fauna of Molokai and Lanai before any further action be taken.

The Star Bulletin (Nov. 25) quoted the Governor as saying of the students, "Their letter to me asked questions that should be answered before the State reaches a decision on the deer importation." Burns said that the students impressed him with their great interest in preservation of Hawaii's ecology, and with their "fair-minded" approach. "They did not charge political pressure," he said. "They did not insist their view was the only view. They asked for further study."

The students' general statement was written by Steve Montgomery, a student in entomology. It raised the question as to whether hunters in Hawaii can have exotic animals for sport while the islands still retain the quality of their native ecosystems. Attention was drawn to Hawaii's unique identity as an ecosystem isolated by a wide expanse of ocean, and to the fact that our responsibility to natural habitats is not only a practical but an ethical question. A reexamination of man's relationship to the environment was suggested, with an emphasis on lessening abuse. The statement concluded with the question, "Can Hawaii adapt to axis deer?" As individuals with some biological background, the students took a stand that Governor Burns understood and appreciated. He told the newspapers, "They said their concern is based on the premise that mankind is seen now as 'one with the earth' rather than as 'master of the earth'." "I agree," Burns said he told the students. (Honolulu Advertiser Nov. 25, 1969; A-8).

In response to the governor's decision that further study was needed on the axis deer question, and to the lobbying efforts of students, scientists and others, the 1970 State Legislature created Act 195 relating to the protection of indigenous fish, bird, animal and vegetable life. The act attempted to address the broad questions relating to the ecology of the islands' animals and plants as brought out during the axis deer debate. The Act established within the DLNR an Animal Species Advisory Commission (ASAC) which serves in an advisory capacity to the Fish and Game Division. The ASAC consists of 11 members appointed by the governor: the chairman of the Division of Fish and Game, the four chairmen of the Fish and Wildlife Advisory Committees appointed by the Governor for each county from local persons knowledgeable in fishing, hunting, and the conservation of wildlife, and six scientists in the fields of botany, mammalogy, ichthyology, entomology, ornithology, and invertebrate zoology. The law states that the ASAC is to advise the Division of Fish and Game on every proposal for the deliberate introduction of animal species into any habitat within the state.

Act 195 set up specific study procedures which the Fish and Game Division would carry out before deciding whether to recommend the deliberate introduction of an animal. Included are studies of the factors which limit the animal's native distribution and abundance and the probable dispersal pattern of the animal; whether, instead of the proposed introduction, a desirable, ecologically comparable indigenous species could be increased or rehabilitated; and if there would be in any way a threat to the existence or stability of indigenous species or a foreseeable risk of conflict with land use policies. If the introduction were recommended, then Fish and Game would have to test the suitability of the introduction in a controlled experimental area. When the animal was introduced, Fish and Game would then study the animal in its new habitat, including its rate of spread and its impact on the habitat.

Thus, in the summer of 1970, things were looking up for conservation, but delays in appointment of members prevented the ASAC from holding its first meeting until December 1971. At this meeting the axis deer issue was brought up, but discussion was deferred to the January 1972 meeting to allow members to study background material. Discussion continued through April, and public meetings were held by the commission on Molokai and on Hawaii to receive public testimony. The Star Bulletin and Advertiser (Mar. 7, 1972; p. A-1) ran the article "Five Hour Battle Over Axis Deer Ends in Draw"about the ASAC meeting in Hilo. At the meeting, 23 persons testified against the introduction of axis deer---sugar and macadamia growers, cattle ranchers, conservationists, students, and research scientists. Thirteen persons testified for the introduction---hunters, archery club members, the Big Island Fish and Game Association with a 10,000-signature petition and politicians. County mayoral candidate Ikuo Hisaoka urged that the deer be released and allowed to roam at will so that the changes, which he felt would be slight, could be determined.

Meanwhile, in accordance with the new environmental protection regulations, the Chairman of the Board of Land and Natural Resources instructed the Divison of Fish and Game to prepare an environmental impact statement on the proposed introduction of axis deer to the Island of Hawaii. The draft of the environmental statement was completed in August 1973; the ASAC reviewed it and its members expressed approval of its treatment of the deer impact question. However, the statement was not sent to the Office of Environmental Quality Control as required by law if the proposal were to be implemented. This would be an important step in the decision as to whether asix deer would be released on the Big Island, but there the matters rests.

In 1972 the State Legislature passed Act 49, important in animal conservation because it established a bird and mammal conservation program. Act 49 directs DLNR to use land acquisition and all other authority to carry out programs for the conservation, management, and protection of indigenous species of birds and mammals and their associated ecosystems. Through the Division of Fish and Game, the Department is to investigate the species involved and their associated ecosystems in order to obtain the data necessary to determine the status of each species. The Act sets forth the procedures and criteria for determining the status of each species--whether it is endangered, threatened, or not. They are then to compile a list of all indigenous species of birds and mammals giving their range and distribution. The law further directs the office of the Governor to review other DLNR programs with the goals of conservation and protection as stated in the law in mind; the Governor is also to encourage other State and Federal agencies to carry out their programs so that actions authorized, funded, or carried out by them do not jeopardize the continued existence of endangered species. Priority is to be given to endangered species and their ecosystems which are close to worldwide extinction.

The Division of Fish and Game receives Federal financial aid for wildlife restoration from two sources---the Pittman-Robertson fund and the Hunter Safety Program. These funds are derived from excise taxes on guns and ammunition and are distributed to the states on the basis of size and the number of licensed hunters. Normally the funds are used for projects directed to game species. ASAC members have noted that on the mainland the terms wildlife, game animals and native animals are often synonymous, but in Hawaii there are no native game animals, and programs for the "restoration" of game animals in Hawaii cause damage to the native wildlife.

Scientist members of the ASAC have severely criticized the last two

Pittman-Robertson proposals which set forth in detailed description major Fish and Game projects to be undertaken for the year. These members found the proposals lacking in provisions for protecting and restoring endangered Hawaiian wildlife and other native biota. It was suggested in a memorandum from the Commission to the Division of Fish and Game that game management practices must be based on safe carrying capacities of the native habitats, not on maximum hunter bag-yields as at present.

According to information gathered by Senator Daniel Inouye in 1973, there are no restrictions on the use of these funds for endangered species, but that the initiative for such programs rested with the States. Federal legislation to implement action on endangered species resulted in the 1973 Endangered Species Act which recognizes, among other things, that in order to conserve an endangered species, the habitat in which the species occurs must be conserved. By this act Congress appropriated ten million dollars to be used over the next three years to meet up to 2/3 of the cost of state programs for the conservation of endangered and threatened plant and animal species. Since, on the federal list, Hawaii has 1/5 of the endangered animals, including ½ of all endangered birds, it should be able to benefit from these funds.

At about the same time that news of this Federal Act was reaching Hawaii, the ASAC was threatened by House Bill 2150 of the 1974 Legislative Session. The bill concerned proposed deletions and insertions in the act which established the ASAC. Most of these changes weakened the commission and the checks upon importation of animals that it provides. The changes would help to clear the way for the introduction of axis deer to Hawaii. In public hearings befor the House and the Senate Committees, the axis deer issue flared again as a rallying point for both sides. The bill was introduced by Kauai representative Richard Kawakami, chairman of the House Water, Land Use Committee, who belonged to the Kauai Sports and Commercial Fishing Club and was said to be sympathetic to Kauai hunting interests. The power of the hunters is strongest on the neighbor islands where the rural way of life still holds sway. Neighbor island legislators hold key chairmanships and positions in the State House and Senate. The hunter and gun club groups are politically active locally and nationally, organized for lobbying for their stated interests.

House Bill 2150 passed the House and went to the Senate where it was referred to Big Island Senator John Ushijima's Judiciary Committee. Conservationists were shocked that the bill did not go to the seemingly more appropriate committeee on Ecology, Environment and Recreation headed by environmentally-conscious Senator Kenneth Brown. It was felt that some strings had been pulled by hunter interests in this referral. A vigorous telephone and letter campaign was organized by conservationists in an attempt to forestall the passage that seemed likely. Despite a declaration that it would not hold a public hearing as it was so late in the session, the Judiciary Committee---apparently yielding to the intense public interest that was voiced---held a public hearing.

The morning hearing was packed, more testimony was ready to be given than the time available before the 11:00 a.m. senate session would allow. The Judiciary Committee did not send the bill out to a floor reading and so it died in committee. HB 2150 reappeared this year with a new number, 489, but with few changes. Testimony against the bill was strong at the recent March 6 public hearing. The bill was not sent out of the House by the deadline so that it is apparently dead for this session.

The ASAC is a thorn in the side of the Division of Fish and Game; it is a roadblock and an obstacle, a source of delay and of derailed business. Hunters demand the traditional American game management service. Hunters, such as Earl Pacheco, former ASAC commission member, are irritated by the demands for study by scientists who, as Pacheco testified at the last year's Judiciary Committee public hearing, "set themselves up as gods."

At present, the ASAC is considering several problem areas. One of these is the feral sheep which are severely threatening the mamane-naio ecosystem on Mauna Kea. Courses of action to remedy the problem are being debated.

The ASAC was asked by a Senate resolution to evaluate the Division of Forestry's five-year forest planting plan for 1972-76 and the attendant environmental impact statemetn. Criticism was made of proposals to clear native forests for planting of exotic timber trees which would threaten the integrity of many areas. Many positive suggestions such as the increased silviculture of native trees were also made.

Endangered species received legislative attention in the form of four bills during the ongoing session. Two of these have survived as of this writing. The bills, one from the House one from the Senate, appear identical. The bills would amend the above discussed Act 49 as related to the conservation, management, and protection of endangered or threatened species of wildlife or plants, instead of just birds and mammals. Conservationists recommended a few revisions of the bill which may be incorporated since the bills, which will presumably be made into one in the end, are still subject to revision.

Progress has been made in the conservation of native ecosystems, but it is a slow battle against certain traditional views and activities. Attitudes of the DLNR, as reflected in their annual reports to the Governor have changed somewhat in their orientation since 1968. More emphasis is being placed on endangered species programs. Each report reflects the Governor's goals for the year, which in turn reflect, to some extent, the most pressing concerns of the people. As the attitude of the people changes, so does the political climate. As the political climate changes, so does legislation.

EDITOR'S NOTE: We begin this volume of the *Newsletter* with an entirely new format, perhaps a bit startling at first but one which hopefully will prove acceptable to all. The decision in favor of such changes was not made lightly; some of the points which we considered are as follows:

1. many of those who keep their copies of the *Newsletter* on file found the page size formerly used very awkward. Often-narrow margins made binding of any sort difficult.
2. a number of worthy notes and articles have appeared in past issues. However, they are usually difficult to find. Unitl an index can be prepared, the detailed table of contents should help.
3. several signed columns are being established--Dr. Lamoureux's annotated "Recent Pacific Publications" is the first. Contributions are solicited, and may be sent to me for forwarding.

The cover was designed by Arnold Wong, a student in the Art Department at the University of Hawaii, and donated by Derral Herbst.

INSTRUCTIONS TO AUTHORS:

Articles for the *Newsletter* are always urgently needed. *Manuscripts*, all of which are reviewed, should be typewritten and double- or triple-spaced with wide margins on 8½ x 11" paper. If possible, they should be submitted in duplicate. Articles in this issue may be used as a guide to suitable format. *Line drawings* must be in India ink; each plate cannot exceed 8½ x 11" (with at least 1" margins all around) when submitted. Use letters to indicate individual figures. *Photographs* are acceptable, but the quality of reproduction cannot be guaranteed. Cost of plate preparation must be borne by the author. Line drawings and photographs must be kept separate. For all illustrations each caption must be on a separate sheet; if a scale is not incorporated into the figure, magnification (after reduction to our 8½ x 6½" page) indicated. *Reprints*, provided at cost as copies of an entire issue, should be ordered when the manuscript is submitted. *Separates* may be requested, but due to the smaller printing, will be more expensive.

CALENDAR OF UPCOMING EVENTS

APRIL

7 Bot. Soc. Meeting. St. John 011. 7:30 pm. Art Whistler, graduate student in Botanical Sciences, Univ. of Hawaii. An illustrated talk about Samoa.

21 Hawaii Audubon Society Meeting. Waikiki Aquarium. 7:30 pm. Ben Okimoto, Animal Science Department, will speak on "Parasites of the Pacific Golden Plover, and their uses in studying migratory habits."

MAY

12 Bot. Soc. Meeting. Kaimuki Branch Library (corn. Harding-Koko Head Aves.) 7:30 pm. Mr. William Mull, an illustrated talk on insects and land snails of Hawaii. A joint meeting with the Hawaii Audubon Society.

ALOHA to the following new members: Nadaraja Balakrishnan (Department of Botany, University of Hawaii)....Ramona Gaber (Department of Botany, University of Hawaii)...Paul K. Higashino (6304 Kaiwiki Place, Honolulu)..Don Hodel (Department of Horticulture, University of Hawaii)..Jim Jacobi (Department of Botany, University of Hawaii)..Terry Parman (P.O. Box 178, Volcano)..Karen Shigematsu (Department of Botany, University of Hawaii)...Rick Warshauer (Department of Botany, University of Hawaii)...Layne Yoshida (Department of Botany, University of Hawaii).

Newsletter,
Hawaiian Botanical Society,
c/o Department of Botany,
University of Hawaii,
Honolulu, Hawaii 96822.

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Newsletter
Hawaiian Botanical Society

Contents

VOLUME 14 NUMBER 2 APRIL 1975

PORTULACA PILOSA SSP. VILLOSA; ECOTYPE OF P. PILOSA OF GREAT VARIABILITY AND ADAPTABILITY
by H. Leith, J. H. Leith & A. Leith. 23

CONSERVATION COLUMN--UPDATE ON PROPOSALS IN THE EIGHTH STATE LEGISLATURE
by R. Gay. .25

RECENT PACIFIC PUBLICATIONS - 1.
by C. H. Lamoureux 26

BRIEF REPORTS AND NOTES
SOCIETY BUSINESS...22; NEW MEMBERS...22; *Bridges*-SEA-GRASS ECOSYSTEM STUDY...31; *Herbst*-BOOK REVIEW ...32; NAMES AND NOTES...33; CALENDAR OF UPCOMING EVENTS...35.

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE REGULAR MEETING OF FEBRUARY 3, 1975

The meeting was called to order at 7:30 p.m. by the president, Derral Herbst. The minutes of the previous regular meeting were read and approved as corrected. The treasurer presented his monthly report. There were 29 members and 19 guests in attendance.

Ruth Gay announced workshops to be held February 4 and 6 concerning the 1975 Regional Plan for Hawaii for water, land, and related resources. The sponsors were looking for long-term information from citizens. Another announcement was for the "Save Diamond Head Association" hearings to be held on February 5 and 12.

It was moved and seconded that the Society pay one-half of the transportation costs for Bill Mull so that he might present a joint meeting lecture to the Audubon Society and the Botanical Society in May. The motion passed unanimously.

Anyone knowing the location of a specimen of *Cupressa funambris* was asked to contact the president.

Dr. Lamoureux introduced the speaker, Dr. Allison Kay, who spoke on "Natural Landmarks in the Pacific."

The president displayed a plant collected by John Obata and named *Gouania gagnei* by Dr. St. John for Wayne Gagné.

Refreshments were served by Ruth Gay.

Jean Maka, Secretary

ALOHA to the following new members: Winona Char (Department of Botany, University of Hawaii)....Colleen K. Hera (2123 Waiola Street, Honolulu)....Erik Sandberg-Diment(310 W 106 Street #16A, New York)...Linda Smith (44-135 Kalenakai Place, Honolulu)....David L. Spargo (P.O. Box 29757, Honolulu)....Art Whistler (Department of Botany, University of Hawaii)....Aiea High School Library....Our Redeemer Lutheran School Library.

Volume 14 Number 1 was mailed April 2, 1975.

PORTULACA PILOSA SSP. *VILLOSA;* ECOTYPE OF *P. PILOSA* OF GREAT VARIABILITY AND ADAPTABILITY

Helmut Lieth, Johann Heinrich Lieth and Armin Leith
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Portulaca pilosa ssp. *villosa* is, in older Hawaiian floras, usually recognized as an endemic species: *P. villosa* (cf Hillebrand 1888). Degener (1937-38) lists two related species: *P. cyanosperma* and *P. hawaiiensis*. The two species *P. cyanosperma* and *P. hawaiiensis* are mentioned again in Fosberg's list of vascular plants in the Hawaii Volcanoes National Park (*in* Doty and Mueller-Dombois 1966). However the ranges given for both species do not cover the locality of our specimen and Fosberg lists *P. hawaiiensis* as dubious species. Recently Geesink (1969) analyzed the species and put all *pilosa*-like types into one species with many subspecies, including the Hawaiian population, from various parts of the world. This short notice presents evidence that it might not even be justified to distinguish some of Geesink's subspecies because of the extreme variability of the species in response to environmental parameters.

In June 1967, the first junior author (J.H.L.) collected specimens of *Portulaca pilosa* ssp. *villosa* sensu Geesink from the Hilina Pali Trail in the Hawaii Volcanoes National Park where it was very abundant. When the field press was opened a few weeks later in Chapel Hill, the two junior authors found that the specimen was still living and decided to plant it and to see if it would continue to grow. This it did, and recognizing it as a Hawaiian endemic very similar to *P. pilosa* populations the senior author knew from other parts of the world, we decided to cultivate the plants for experimental purposes.

The plants were transferred to several pots in July 1967 and kept for three subsequent years, outdoors during the summer months (May-October) and indoors during the winter months. Parts were kept outdoors to see whether the plants were cold tolerant. In 1970 all plants were accidentally kept outdoors late in the season and killed by an early frost. In all pots, however, new plants developed from seeds and swollen roots during the following spring. The specimens that developed were subjected to various treatments because we were then reasonably sure that the Hawaiian population of *P. villosa* were physiologically very similar to the *P. pilosa* we knew from temperate areas.

We noticed during the first three years that our plants changed their new growth's morphology during the course of each year. Outdoors in the Chapel Hill summer climate they developed far fewer hairs than we had observed on specimens in their natural habitats in Hawaii; during the winter we observed axillary hairs appearing again. We therefore grew the same plants during the next two years consistently under two different conditions:

1. High temperature (20-35°C), low humidity (20-35% R.H.), short days (<14 hrs.) and dry soil (soil moistened twice a week which resulted in almost

air dry soil before remoistening). We regard this treatment as adequate to simulate the conditions of the natural habitat in Hawaii. The treatment lasted from October 1971 until May 1972. Similar treatment was resumed in September 1972 and lasted until April 1973.

2. High temperature (25-35°C), high humidity (85-100%R.H.), longer days (>14 hrs.), and continuously moist soil (soil was moistened more than once a day; as the plants were kept outdoors they also received rain in addition to sprinkling). This treatment lasted from May 1972 until August 1972. We regard this treatment as a simulation of the environmental conditions for a population growing in humid, warm, temperate, or tropical conditions.

After treatment 1 was resumed in September 1972, the plants responded by gradually shedding all their leaves which took about three months. While the leaves dropped, the barren branches developed a thick pelt of axillary hairs. New leaves began appearing in December 1972. The new branches resembled, in May 1973, their habit in May 1972.

Portions of the plants were taken and pressed for reference in September 1972 and April 1973. The specimens are kept in the UNC Herbarium, sheet number 425420.

Our conclusions from this sequence of experiments are:

1. The Hawaiian population of *Portulaca pilosa* (ssp. *villosa*) is potentially perennial but may be reestablished from seeds and roots if killed by cold temperatures.

2. The plants are so tolerant against changes of certain environmental forces that they can survive easily in climates ranging from short days, low light intensity, low humidity (desert condition) to long days, high temperature, high light intensity, high humidity (subtropical humid conditions).

3. The variability of morphological characters important for taxonomic purposes in the genus *Portulaca* in response to environmental changes is such that a separation of subspecies seems unwarranted on the grounds of these characteristics. The reduction of a number of subspecies described by Geesink to ecotypes or varieties seems therefore more adequate.

4. From the above described experiments and additional observations of populations of *P. pilosa* from North Carolina we suggest that the *P. pilosa* complex be subjected to a thorough biosystematic study for further taxonomic treatments.

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Geesink, R. 1969. An account of the genus *Portulaca* in Indo Australia and the Pacific (Portulacaceae). Blumea 17: 275-301.

Hillebrand, W. 1888. Flora of the Hawaiian Islands. Carl Winter. Heidelberg: 673 p.

Ed. note. Three photographs were submitted with this manuscript which, due to the printing process used for the Newsletter, *unfortunately could not be used. I have them on file and they may be examined by interested persons.*

CONSERVATION COLUMN

UPDATE ON PROPOSALS IN THE EIGHTH STATE LEGISLATURE

R. Gay
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University of Hawaii - Manoa

A single *State Endangered Species Bill* (Senate Bill 1665, Senate Draft 2, House Draft 1) has been forwarded to the Governor for his signature. This bill provides programs and protection for endangered and threatened wildlife and plant species on the Federal Endangered Species List. In addition, indigenous species not on the Federal List may be added to or removed from a State List of Endangered and Threatened Species. Stated criteria for endangered species include overutilization, disease, predation, threatened habitat and inadequate regulation. House Draft 1 also includes the provisions of Chapter 191 of the Hawaii Revised Statutes that were deleted from the original bill; thus the bill now specifies conservation programs for any indigenous plants, birds and mammals and their associated ecosystems. If signed into law, this bill will qualify Hawaii for federal funds under the Federal Endangered Species Act of 1973. Enactment would be an important legislative landmark for the protection of plants.

The *Exceptional Tree Bill,* formerly SB 1372, was sent to the Governor as SB 106, SD 1. The provisions in the two bills are identical. Under the bill, each County Arborist Advisory Committee shall include the County Planning Director, a landscape architect and not less than three other members selected on the basis of active participation in programs of community beautification or ecology, including ethnobotany or Hawaiiana.

Senate Resolution 240 pertaining to the biocontrol of *Clidemia hirta* was adopted. The resolution directs the Department of Agriculture to review the problems associated with this noxious weed and to report findings to the Senate by 1976.

Senate Resolution 397 requests the establishment of a native rare tree sanctuary in the Puuwaawaa area on the Island of Hawaii. As adopted, this resolution directs the Division of Forestry to set aside a sanctuary for rare native trees on land now leased to Puuwaawaa Ranch.

Other measures described in the last *Newsletter* which were not passed during the legislative session, however, may be reactivated during the next session. *SB 1518*, appropriating money for the protection and preservation of endangered species on Hawaii, is in the Senate Committee on Ways and Means. *SB 970* relating to a fencing proposal on Mauna Kea is in the Senate Ecology, Environment and Recreation Committee. *HB 489* pertaining to the Animal Species Advisory Commission is in the House Committee on Energy and Transportation.

RECENT PACIFIC PUBLICATIONS - 1.

C. H. Lamoureux
Department of Botany
University of Hawaii - Manoa

BAKER, G. E., P. H. Dunn and W. A. Sakai. 1974. The roles of fungi in Hawaiian ecosystems I. Fungal communities associated with leaf surfaces of three endemic vascular plants in Kilauea Forest Reserve and Hawaii Volcanoes National Park, Hawaii. US/IBP Island Ecosystems IRP Tech. Rept. 42. 46 p.---Fungi associated with leaf surfaces of *Metrosideros collina* var. *polymorpha, Acacia koa,* and *Cheirodendron trigynum* var. *trigynum* were analyzed. Total *Metrosideros* community was three times greater than that of *Acacia*. From *Metrosideros* 40 species of fungi were recovered, 30 from *Acacia*.

BISHOP, L. E. 1973. Honolulu Botanic Gardens Inventory 1972. Honolulu: Friends of Foster Garden Press. 293 p.---Brief history of the various branches of the Honolulu Botanic Gardens, and an inventory (including name of plant, accession number, source of material, and branch garden where material is growing) of the plants growing there in 1972. With 11 plates, black and white drawings by Sue Monden, showing plants cultivated in the Gardens.

-----. 1974. Revision of the genus *Adenophorus* (Grammitidaceae). Brittonia 26: 217-240.---A revision of the endemic Hawaiian fern genus *Adenophorus* (also known as *Amphoradenium* by earlier Hawaiian botanists) which recognizes eight species (one with three varieties) and one hybrid. New taxa are *Adenophorus* subgen. *Oligadenus, A. periens,* and *A. tamariscinus* var. *epigaeus*. New combinations are *A. oahuensis* and *A. tamariscinus* var. *montanus*.

----- and D. Herbst. 1973. A new *Hibiscadelphus* (Malvaceae) from Kauai. Brittonia 25: 290-293.---*Hibiscadelphus distans* described from a very small remnant population in Waimea Canyon, Kauai. This is a significant extension of range for the genus otherwise known from 4 species on Maui and Hawaii. *H. distans* is an endangered species, as are *H. giffardianus* and *H. hualalaiensis*, while *H. wilderianus* and *H. bombycinus* are probably extinct.

BRYAN, E. H., Jr. 1974. Panala'au Memoirs. Honolulu: Pacific Scientific Information Center, Bishop Museum. 249 p.---The story of the colonizing of Jarvis, Howland, Baker, Canton, and Enderbury Islands by the U.S. Department of Interior and Commerce between 1935 and 1941, based largely on diaries of the colonists. Casual notes on plants, and on attempts at farming on these islands. Maps and photographs.

COORAY, R. G. 1974. Stand structure of a montane rain forest on Mauna Loa, Hawaii. US/IBP Island Ecosystems IRP Tech. Rept. 44. 98 p.---In the Kilauea Forest Reserve structural analysis shows that *Acacia koa* is maintaining itself, contrary to the suggestion that it is not adequately reproducing and may be gradually disappearing from montane rain forest. Koa was present in all size-classes with 4 times as many seedlings and suckers as mature trees. Successful reproduction usually occurs on root collars of wind-thrown trees, in places where young plants are not subject to disturbance by rooting pigs. It is suggested that feral pigs may cause an overall deterioration of this montane rain forest.

DEGENER, O. and I. Degener. 1973. *Santalum paniculatum* var. *chartaceum* Deg. & Deg. Phytologia 27: 145-147.---New variety described from a single tree growing in Fern Forest Estates, Puna, Hawaii.

----- and -----. 1974. Flotsam and jetsam of Canton Atoll, South Pacific. Phytologia 28: 405-418.-- Discussion of the role of oceanic drift in plant dispersal. Consideration of what happens to seeds after they come ashore as part of the beach drift. List of more than 50 species of plants, the seeds of which were found on Canton beaches.

----- and -----. 1974. *Spathodea* in Hawaii. Phytologia 28: 419-420.---Three taxa recognized for Hawaii. *Spathodea campanulata* is the common African tulip tree with glabrous leaves, scarlet flowers, and a silky tomentulose calyx with elevated nerves. *S. nilotica* has leaves densely tawny puberulent beneath, scarlet flowers, and a silky tomentulose calyx with impressed nerves. A newly described form, *S. nilotica* forma *bryanii* Deg. & Deg. has "pumpkin-yellow" flowers.

----- and -----. 1974. Bishop's "Inventory." Phytologia 28: 420-421.---Review of Bishop, 1973.

FRIEND, D. J. C. 1974. Shade adaptation of the Hawaiian tree-fern (*Cibotium glaucum* (Sm.) H. & A.). US/IBP Island Ecosystems IRP Tech. Rept. 41. 39 p.---Sporophytes and gametophytes of *Cibotium glaucum* demonstrate both physiological and morphological adaptations to low light intensity typical of shade plants. The sporophytes also show one feature associated with sun plants - the rate of light saturated photosynthesis increased with increasing irradiation during growth. This is presumably related to the emergence of the sporophyte from the extreme shade habitat typical of the gametophyte.

GILLIS, W. T. and W. T. Stearn. 1974. Typification of the names of the species of *Leucaena* and *Lysiloma* in the Bahamas. Taxon 23: 185-191.---Recent research has revealed that the correct botanical name for the koa haole is *Leucaena latisiliqua* (L.) Gillis. This is the oldest available name for the plant and replaces the names *L. leucocephala* and *L. glauca* which have commonly been used by Hawaiian botanists.

HOE, W. J. 1974. Annotated checklist of Hawaiian mosses. Lyonia 1: 1-45.---This is the first number of a new publication, subtitled "Occasional Papers of the Harold L. Lyon Arboretum," which will appear at irregular intervals and will be available from the Arboretum, 3860 Manoa Road, Honolulu, Hawaii 96822. The checklist gives accepted scientific names and notes on distribution of the 255 species, varieties, and forms of mosses recorded from the Hawaiian Islands. 130 (51%) of the taxa are considered to be endemic to Hawaii.

JACOBI, J. D. 1974. A vegetational description of the IBP small mammal trapline transects - Mauna Loa Transect. US/IBP Island Ecosystems IRP Tech. Rept. 48. 19 p.---For sampling small mammals and associated ectoparasites, 18 traplines were established along the IBP Mauna Loa Transect. The locations and descriptions of the vegetation along each of these lines are described.

KARTAWINATA, K. and R. Atmawidjaja (eds.). 1974. Coordinated study of lowland forests of Indonesia. Bogor, Indonesia: Regional Center for Tropical Biology (BIOTROP) and Faculty of Forestry, Bogor Agricultural University (IPB). 183 p.---Papers given at a symposium concerned with coordinating studies of inventory, utilization, and conservation of natural resources in lowland forests of Indonesia. Among the papers are some dealing with use of ERTS-A imagery in forest inventory; a list of the 157 nature reserves in Indonesia and a list of protected animals; assessment of needed research in forestry.

KLIEJUNAS, J. T. and W. H. Ko. 1974. Deficiency of inorganic nutrients as a contributing factor to ohia decline. Phytopath. 64: 891-896.---Declining trees treated with complete fertilizer (NPK + micronutrients) responded by producing numerous new leaf buds on branches and trunks. Trees also responded to NPK without micronutrients. N, P, and K applied individually or with micronutrients were not effective. Declining trees responded to combinations of NP but not to NK and PK.

LAMOUREUX, C. H. and S. Djirman. 1974. Report on the Rumphius Expedition I. 7. Observations on the flora and vegetation of southern Maluku. Oseanologi di Indonesia 1974, No. 1: 46-60.---Descriptions of vegetation at various shore stations on the islands of Ambon, Seram, Haruku, Saparua, and Nusa Laut, in the southern Moluccas, during Rumphius Expedition I in January 1973. A list of plant collections is given.

LEE, M. A. B. 1974. Distribution of native and invader plant species on the island of Guam. Biotropica 6: 158-164.--On Guam native plant species are largely woody and successful invaders largely herbaceous. Invasion was most successful in areas with large proportions of widely distributed native species (indigenous species), and less successful in areas with large proportions of endemic species. Invaders from the New World outnumber those from the Old World, but Old World invaders proved to be more effective in establishing themselves in highly organized, complex vegetation communities.

LLOYD, R. M. 1974. Genecological studies on Hawaiian ferns: reproductive biology of pioneer and non-pioneer species on the island of Hawaii. US/IBP Island Ecosystems IRP Tech. Rept. 35. 29 p.---Mating systems and frequency of recessive lethal genes (genetic load) were studied in ferns occupying pioneer lava flow and mature rainforest habitats. Species dominant in pioneer habitats were characterized by intragametophytic mating systems and no genetic load; those from rainforest habitats exhibited complex intergametophytic mating systems and higher levels of genetic load.

* MUELLER-DOMBOIS, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. New York: John Wiley & Sons. 547 p.---A textbook dealing with the concepts and methods of plant synecology or vegetation ecology. Most of the book is devoted to detailed descriptions of methodology, and the interpretations of results obtained using different methods. The book is of importance to anyone concerned with vegetation sampling.

ST. JOHN, H. 1974. New *Pandanus* species from New Guinea and Bougainville Island. Contr. Herb. Australiense 3: 1-6.---Two new species, *P. bowersae* and *P. schoddei*, are described.

-----. 1974. Revision of the genus *Pandanus* Stickman. Part 36. The new section *Asperi* from Indomalaya. Pacific Sci. 28: 79-82.---Description of a new section and one new species, *P. asper*, from Sumatra.

-----. 1974. Revision of the genus *Pandanus* Stickman. Part 37. *Pandanus* on Aldabra Island, Indian Ocean. Pacific Sci. 28: 83-100.---Six species recognized, all described as new, all endemic.

-----. 1974. The vascular flora of Fanning Island, Line Islands, Pacific Ocean. Pacific Sci. 28: 339-355.---Flora of 102 species and varieties includes 39 ornamentals, 13 food plants, 28 adventives, 20 indigenous plants, and 2 endemics. One new species (*Pandanus fanningensis*) and a new cultivar (*Pandanus tectorius* var. *novi-caledonicus* cv. "Kaina") are described.

SKOLMEN, R. G. 1974. Some woods of Hawaii...properties and uses of 16 commercial species. U.S.D.A. Forest. Serv. Gen. Tech. Rept. PSW-8. 30 p. ---For 16 Hawaii-grown species notes on tree characteristics, history, size, growth rates, available timber volume, and accessibility are given. Wood properties such as appearance, weight, shrinkage, strength, workability, seasoning, durability, and finishing are described. Color photos of each wood are included.

-----. 1974. Lumber potential of 12-year-old Saligna eucalyptus trees in Hawaii. U.S.D.A. Forest. Serv. Res. Note PSW-228. 7 p.---Lumber was predominantly of low grade, but of lower average density than wood from older trees, and therefore more desirable. Logs end-split badly and sawed with difficulty. Wood shrank moderately in drying, but lumber degrade was not serious. Bending strength was high for the specific gravity. Wood nailed, machined, and glued reasonably well, but did not accept preservative when pressure treated.

-----. 1974. Natural durability of some woods used in Hawaii...results of 9½ years' exposure. U.S.D.A. Forest. Serv. Res. Note PSW-292. 6 p.---Tests include stakes set in ground and post-rail units above ground at Makiki, Oahu. Of 15 woods tested redwood was most durable, followed by 3 eucalypts-blackbutt, saligna, and robusta. White oak, western hemlock, and tropical ash were least resistant.

SMITH, A. C. 1973. Studies of Pacific Island plants. XXVI. *Metrosideros collina* (Myrtaceae) and its relatives in the southern Pacific. Amer. Journ. Bot. 60: 479-490.---In the southern Pacific, from the New Hebrides eastward to the Society and Tuamotu Islands, there are three varieties of *Metrosideros collina*, as well as two local endemic species, *M. gregoryi* in Samoa and *M. ochrantha* in Fiji.

-----. 1974. Studies of Pacific Island plants. XXVII. The genus *Gardenia* (Rubiaceae) in the Fijian Region. Amer. Journ. Bot. 61: 109-128.---In the Fijian Region (Santa Cruz, Banks, and New Hebrides Islands, Fiji, Rotuma, the Horne and Wallis Islands, Samoa, Tonga, and Niue) there are 11 indigenous species of *Gardenia*, 8 of which are endemic to Fiji. The three Hawaiian species are each related to different Fijian endemics, which suggests that three separate original immigrants to Hawaii should by hypothesized.

----- and S. P. Darwin. 1974. Studies of Pacific Island plants. XXVIII. The Guttiferae of the Fijian Region. Journ. Arnold Arbor. 55: 215-263.---In the Fijian Region (Santa Cruz Islands and New Hebrides to Tonga and Samoa) there are nine species of *Calophyllum*, two of *Mammea*, and five of *Garcinia*.

THAMAN, R. R. 1974. *Lantana camara:* its introduction, dispersal and impact on islands of the tropical Pacific Ocean. Micronesica 10: 17-39.---A summary of the introduction of lantana to various Pacific islands, the spread of lantana in each island group, an analysis of the factors which have allowed it to become naturalized, and the impact it has had upon the vegetation of different island groups. Based largely on a literature survey, the paper presents lots of useful data and an extensive bibliography.

WATSON, D. P. and W. L. Theobald. 1974. Ornamental gingers in Hawaii. Amer. Horticulturalist 53, No. 4 (Fall 1974): 20-29.---Brief descriptions and color photos of 16 common ornamental gingers.

WHITESELL, C. D. 1974. Effects of spacing on loblolly pine in Hawaii after 11 years. U.S.D.A. Forest Serv. Res. Note PSW-295. 4 p.---On Maui *Pinus taeda* is planted at spacings of 6, 8, 10 and 12 feet. After 11 years average d.b.h. and percent of stem in line crown was greatest in 12 foot spacing, basal area greatest in 6 foot spacing, with no significant difference in height growth.

WIRAWAN, N. 1974. Floristic and structural development of native dry forest stands at Mokuleia, N. W. Oahu. US/IBP Island Ecosystems IRP Tech. Rept. 34. 56 p.---Almost all species recorded in 1950 from 7 plots in native dry forest stands in Mokuleia are still found in their respective plots. Except in 2 plots, almost all dominant native species are regenerating and maintaining themselves. If undisturbed by animals or fire, native forests can maintain themselves, although shade-tolerant introduced species seem to remain as minor components of these forests.

NEW PERIODICAL

Notes from Waimea Arboretum. A periodical publication on plants and the work of the Waimea Arboretum. It will contain checklists of plants in the arboretum and an Index Seminum. Vol. 1, No. 1 pub. June 1974, No. 2 pub. Dec. 1974. Available from Waimea Arboretum, 59-864 Kamehameha Hwy., Haleiwa, Hawaii 96712.

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* Assigned for review.

SEAGRASS ECOSYSTEM STUDY

In August, I received a research grant from the National Science Foundation for an 18-month study of the distributional patterns of seagrass ecosystems. This research also involves the "conceptual modelling" of these ecosystems. With this modelling, we are trying to synthesize what knowledge we have of entire ecosystems. Cooperating with this research, by means of separate grants, are research groups in Alaska, Washington, Texas, Michigan, Virginia, and the Virgin Islands. This multi-University research team works closely together by means of tightly coordinated research designs and the rapid dissemination of results. Obviously, trying to achieve this kind of communication is an experiment in itself.

Seagrasses are aquatic angiosperms which are adapted to living in a marine environment. This group of about 50 species includes the genera *Zostera* and *Thalassia* (generally known as eel grass and turtle grass). These plants function when fully submerged, even completing their life-cycle as flowering plants.

Seagrass meadows constitute one of the most common and extensive coastal ecosystems but are rarely recognized as an important living marine resource. However, enough documentation now exists to show that this system is extremely important locally, especially to the common man rather than to large-scale industry. The diversity of this local utilization is reflected in the following selected examples: in Florida seagrass beds are necessary nursery grounds for species of commercial shrimps; in Alaska the seagrass beds provide the subsistence for a large portion of the migratory waterfowl of the Pacific flyway; in Australia the plants are the sole food item of the dugong; throughout the Indo-West Pacific seagrasses are a prime food item of the milkfish, the vital subsistence fishery of the region; in the Caribbean the green sea turtles depend on seagrass for food. In most of the tropics coral reef ecosystems appear to be bound intimately to adjacent seagrass beds through fish and invertebrate herbivore food chains. Transported seagrass leaves are even a food resource for many animals in the deep-sea tranches. There are also numerous examples of the value of seagrass beds in stabilizing and protecting coasts; the turtlegrass beds of the southeastern U.S. offer some protection from hurricanes to lowlying coasts.

Seagrasses do not appear to be very "important" in Hawaii. We do have one species, *Halophila hawaiiana,* which occurs on Oahu, Kauai and Maui. However, the local distribution pattern is not completely known. New evidence is coming in rapidly, showing that this is really quite a common plant of many shallow water regions. Since our work is just getting underway, the importance of this species has not been assessed.

The last workshop meeting of the entire research group was held in Honolulu in early March.

K. W. Bridges
Co-Principal Investigator
Seagrass Ecosystem Study
Department of Botany
University of Hawaii - Manoa

BOOK REVIEW

Sutton, S. B. 1974. In China's Border Provinces. The Turbulent Career of Rock, Botanist-Explorer. New York: Hastings House. 334 p. $9.95.

"Our coolies cry out constantly as we are carried through the narrow streets, 'make room for the foreign devil,' a few boys are angry at me, kick my chair...and then stick their tongues out at me as well as curse me, but in Chinese." Joseph Rock was estatic; his short tour of Canton had fulfilled a youthful dream to see China. During a lonely, unhappy childhood in Vienna, Rock had read books about foreign lands and at the age of 13, had started to teach himself Chinese, the language of a country he had found particularly fascinating. No amount of anti-western feelings could dampen his enthusiasm. This fascination, and fate, culminated in his becoming the outstanding scholar of the mountainous western provinces of the Republic of China.

Fate came in the guise of Dr. Herbert Gregory, the Yale-appointed director of the Bishop Museum. It was principally through Gregory's influence that the Hawaiian legislature authorized the transferral of the College of Hawaii's herbarium to the Bishop Museum. While the herbarium was not Rock's personal property, he felt that he had been affronted professionally, and, in a fit of pique, left the Islands. The college herbarium had consisted chiefly of Rock's collections and the duplicates of Hillebrand's specimens that Rock had been able to secure from the Botanisches Museum at Berlin-Dahlem. The latter proved to be a fortunate acquisition, as the Berlin herbarium was destroyed during World War II. All material, including the entire lichen collection of the Bishop Museum previously sent there to be determined by an expert in that group, were lost, except for the fern specimens.

Rock returned to the mainland. By that time he was recognized internationally as an authority on the Hawaiian flora, but there were no positions available for specialists on Hawaiian plants. He learned that the Office of Foreign Seed and Plant Introduction of the U.S. Department of Agriculture wished to introduce seed of *Hydnocarpus kurzii* (the Chaulmoogra tree), a tree native to southeast Asia. The unusual cyclic oils in the seed of this plant were a drastic but useful treatment for leprosy. Rock jumped at the opportunity and ultimately established himself as a successful, competent agricultural explorer. Under great difficulty he was able to locate the chaulmoogra tree and successfully send its short-lived seeds back to Hawaii, where a small plantation was established. The project soon was abandoned due to the discovery of sulfa drugs, a less drastic and more effective treatment for leprosy. Nevertheless, Rock's reputation had been secured.

Most of the remainder of his life was spent under the aegis of the National Geographic Society, the U.S. Department of Agriculture, and the Arnold Arboretum of Harvard University. Under their sponsorship, Rock was able to explore and map the unknown western provinces of China, a boon to the U.S. during World War II, collect thousands of specimens of plants and birds for museums, collect seeds of hundreds of species of plants of potential horticultural value, and, perhaps most important, complete studies of the language and culture of the Nahki and related tribes of Tibetan origin before they disappeared into the mainstream of the Chinese Communist revolution. It is primarily about Rock's life in China that Miss Sutton writes.

For many years I have been aware of S. B. Sutton's interest in and research on Rock's life. I have read her *Charles Sprague Sargent and the Arnold Arboretum* and rejoiced that such a talented and competent writer should undertake the biography of Hawaii's noted botanist. I now have read *In China's Border Provinces*, and, frankly, am disappointed.

The book is poorly edited, has more than its share of typographical errors, is printed on poor quality paper, is cheaply bound, and is enclosed in a garish, tasteless dust cover. It is written more about the history and politics of China than about Rock's exploration and research. But then, China sells well, and has since Nixon's visit. I frequently had the feeling that the book was not actually about Rock, but rather, Rock's presence in China was seized as an excuse to write another book about that country. As Miss Sutton states in her acknowledgements, there still is need for a study concentrating on Rock's botanical contributions.

If one is able to overcome the disappointment of finding so little about Rock in his biography, then the book is well worth reading. Miss Sutton writes well and has a fascinating tale to tell.

Derral Herbst
Harold L. Lyon Arboretum

NAMES AND NOTES

ROBERT C. GARDNER, a graduate student in botany at the Ohio State University, is studying *Lipochaeta* using chemical, morphological, cytological, and hybridization techniques. He recently presented a talk to the Botany Department entitled "Patterns of adaptive radiation in *Lipochaeta* (Compositae) of the Hawaiian Islands."...*WILLIAM L. THEOBALD*, our Society's past president, has been named to become the director of the Pacific Tropical Botanical Garden at Koloa, Kauai. He will be replacing Dr. William S. Stewart, director of the Garden for the past five years, who will retire on July 1. ... *Professor Emeritus F. C. STEWARD*, a distinguished plant physiologist in the fields of mineral nutrition and plant tissue culture and formerly director of Laboratory for Cell Physiology, Growth and Development at Cornell University, Ithaca, N.Y., visited the University of Hawaii at Manoa campus February 17 through March 3. He presented two seminars, one on "Multiple Interactions between Factors that Control Cells and Development" at the Botany seminar and the other on "How Plants Grow" at the Agronomy seminar. A lecture for the general public, entitled "Facts and Fancies about Cloning Plants and Animals" was delivered to the Society.... *GAYTHER PLUMMER*, Professor of Botany and member of the Institute of Ecology at the University of Georgia, presented a botany research seminar at the University of Hawaii, Manoa on March 6. He described the usefulness of photos recorded by the two earth-resources-technology-satellites (ERTS) in identifying geophysiographic features, communities and aggregate populations of plants, and the impact of fire and human activity. Dr. Plummer has found ERTS imagery particularly effective in the red and far infrared bands when applied to ecological studies of areas greater than 40 acres in size. ...*PETER A. BOWLER* (Dept. of Population & Environmental Biology, Univ. of Calif., Irvine) is visiting for the spring as a Research Associate with the Dept. of Plant Pathology (UH). He is working on the chemical ecology and the evolutionary relationships of the lichen genus *Ramalina* in the Hawaiian Islands. ...Having volunteered more than 600 hours of his time since early February 1974, *MR. FRED HAUGHTON* is now a part-time Museum staff member in the Botany Department of the Bishop Museum. Mr. Haughton is a retired state conservationist for the U.S. Department of Agriculture, Soil Conservation Service. ...*CHARLES H. LAMOUREUX* attended the symposium on "South East Asia Plant Genetic Resources" held in Bogor, Indonesia, from March 20-22, 1975. He presented a paper entitled "Tropical forests in South East Asia: Genetic resources for economic plants other than timber." He also stopped at the University of Singapore, where he is serving as the external examiner on a dissertation on pineapple anatomy. ...The Society has learned of the recent death of Florida-member *MR. HENRY NIES*. Our deepest sympathy to his wife. ...COURSE ANNOUNCEMENT - University of California. "Land and Life: Natural History of Hawaii Island Biology." X 413. Hiking, backpacking on Maui and the island of Hawaii, lectures, etc. Taught by *RICHARD E. WARNER*. June 28-July 6, 1975. Credit: 3 quarter units (two semester units) in forestry and conservation. Fee: $535 per person. Information and application form may be obtained from: Department B, University Extension, University of California, Berkeley, California 94720. ..*HAROLD J. EVANS*, Professor of Botany at Oregon State University and a member of the United States National Academy, recently presented a seminar entitled "Recent investigations on the physiology and biochemistry of nitrogen fixation in legumes" on the University of Hawaii campus. ...*L. F. MOLLOY*, soil organic chemist in the New Zealand Department of Scientific and Industrial Research Organization and currently a Senior Fellow in the Open Grants Program of the East-West Center, recently spoke to the botany research seminar on "Indigenous forestry in New Zealand---A conservation dilemma"..The Animal and Plant Health Inspection Service-Plant Protection and Quarantine Program (APHIS-PPQ) of the United States Department of Agriculture recently underwent major reorganization, with *STANLEY S. MIYAKE,* formerly Inspector-in-Charge of Honolulu, becoming the new Area Director for Hawaii, which includes the Honolulu and Hilo ports. The Hawaii State Department of Agriculture collaborators on Kauai, Maui and Hawaii assisting in the Federal program are coordinated through the Area Director's office. His assistant is *W. O. RIDGWAY* who transferred from the Pink Bollworm laboratory in Phoenix, Arizona. The port of Honolulu includes the International Airport, military bases, maritime, post offices, and a Federal-State cooperative program on plant pests. These sections are rotated among the three assistant inspectors-in-charge: *JULES FINE, SHINYA NAMIKI,* and *EDWARD SHIROMA.* ...The 19th Hawaiian Science and Engineering Fair, sponsored by the Hawaiian Academy of Science, was held at the Honolulu International Center Exhibition Hall April 10-12, 1975. Judges for the Hawaiian Botanical Society were *C. W. SMITH* and *N. P. KEFFORD.* The botany division winners, who receive a copy of Marie Neal's "In Gardens of Hawaii" and a year's subscription to the *Newsletter* for their school library in their names, are: Senior division---*RANDALL S. KIDO* of Aiea High School with "Cyclotic migration rates: a possible key to increasing metabolic rates in the *Elodea* cell" and Intermediate division---*JEFF VAN WINKLE* of Our Redeemer Lutheran School with "A study of pigment variation in *Acanthophora spicifera.*" *Contributions from W. Gagné, R. Gay, D. Herbst, S. Sato.*

CALENDAR OF UPCOMING EVENTS

MAY

4 Humane Society Animal Sterilization Program benefit plant sale. Humane Society Bird Sanctuary (2700 Waialae Ave.). 10 am-2pm. Parking at UH Quarry, with shuttle service provided.

6 Pacific Tropical Botanical Garden, Third lecture of the 1975 Season. McCully-Moiliili Library lecture hall. 7:30 pm. William L. Theobald (University of Hawaii-Manoa), "A future flora for Hawaii."

7 6th Annual Lyon Arboretum Lecture. St. John 011. 2:30 pm. George W. Gillett (University of California-Riverside), "Diversity in the flora of the Hawaiian Islands."

12 Bot. Soc. Meeting. Kaimuki Branch Library (corn. Harding-Koko Head Aves.). 7:30 pm. Mr. William Mull, an illustrated talk on insects and land snails of Hawaii. A joint meeting with the Hawaii Audubon Society.

JUNE

2 Bot. Soc. Meeting. St. John 011. 7:30 pm. Steve Sato, Plant Quarantine Division of the United States Department of Agriculture, will discuss plant importation and exportation regulations.

16 Hawaii Audubon Society Meeting. Waikiki Aquarium. 7:30 pm. John I. Kjargaard, Haleakala National Park, will give an illustrated talk on aerial photography of Hawaii.

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Contents

VOLUME 14 NUMBER 3 JUNE 1975

AN AUTECOLOGICAL REVIEW OF SOPHORA CHRYSOPHYLLA IN HAWAII
by T. Parman .40

BRIEF REPORTS AND NOTES

SOCIETY OFFICERS....38; SOCIETY BUSINESS...39, 53; *Nagata* - LYON ARBORETUM I....50; *Hoe* - FISSIDENS CRUMII...51; *Russell* - RUSSELL..52; NEWS AND NOTES..53; CALENDAR...53; UH RESEARCH ACTIVITIES...55; NOTE OF THANKS...55.

* * *

Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

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MINUTES OF THE REGULAR MEETING OF MARCH 3, 1975

The meeting was called to order at 7:35 p.m. by the president, Derral Herbst. The minutes of the previous regular meeting were read and approved. The treasurer presented his monthly report. There were 51 members and 39 guests in attendance.

Ruth Gay announced a hearing for House Bill 489 concerning the introduction of axis deer to the Big Island. It was to be a joint committee hearing on March 6. Sheila Conant announced a hearing on March 8 for another bill to reduce the power of the Animal Species Advisory Commission.

The auditor, William M. Bush, presented his report and Annual Statement for 1974. A motion to accept his report was passed unanimously.

Announcements of upcoming meetings were made by the vice president, Sheila Conant, who then asked Dr. Kefford to present the speaker. After an interesting introduction, Dr. Steward gave an illustrated presentation on "Fact and fancy about cloning plants and people."

Dr. Hartt displayed a lichen-covered rock from Antarctica and Ted Green showed the group an orchid cloned by mistake and a hoya.

The meeting was adjourned to the plant exchange and refreshments by Beatrice Krauss.

Jean Maka, Secretary

An embarrassed editor apologizes to the Lieths, authors of "*Portulaca pilosa* ssp. *villosa*; ..." whose names were misspelled in the previous issue.

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AN AUTECOLOGICAL REVIEW OF *SOPHORA CHRYSOPHYLLA* IN HAWAII

Terry Parman
Volcano, Hawaii

Page
ABSTRACT 40
TAXONOMY 41
DISTRIBUTION AND COMMUNITY OCCURRENCE 42
DEVELOPMENT AND REGENERATION 44
PHENOLOGY 47
CONCLUDING REMARKS 48
ACKNOWLEDGEMENTS 48
LITERATURE CITED 48

ABSTRACT

Sophora chrysophylla (Salisb.) Seem., the mamane, is one of the more important tree species in the Hawaiian dryland forests (Hosaka and Ripperton, 1944). It was formerly more widely distributed than at present. Both habitat manipulation by man (e.g. landclearing, planting of exotic species) and habitat destruction by exotic feral mammals have been important factors in the decline of this endemic tree. Perhaps the most striking example of this can be seen in the decadent mamane-naio (-*Myoporum sandwicense* Gray) forest on Mauna Kea on the island of Hawaii. There were once over 40,000 feral sheep inhabiting mamane forests on Mauna Kea, and although today this population has been reduced to about 1500, the damage to the forest is so severe that its capacity for regeneration has been considerably reduced.

Besides being an important constituent of xeric forest ecosystems in Hawaii, the mamane is also an important food plant for several species of the unique Hawaiian honeycreepers (Aves: Drepanididae; Berger, 1972). In fact it is the major food source and nesting site of the palila (*Psittirostra bailleui*), a rare and endangered species, of which only 300 birds were observed during an extensive census conducted in January 1975 (van Riper, pers. comm.).

Published information about Hawaiian *Sophora* is scanty. Nevertheless the importance of this tree in Hawaiian terrestrial ecosystems seems to

merit a summary of the information that has been published, as well as some new, unpublished data on mamane regeneration in relation to the effects of grazing by feral mammals.

TAXONOMY

Lack of agreement among taxonomists on the classification of many species in the Hawaiian flora is a recurrent problem. The taxonomy of the endemic species of *Sophora*, commonly known as mamane, is no exception to this situation. Polymorphism, a trait common to many endemic species in insular environments, is by no means absent in Hawaiian plants, and can be observed in the individual variation found within the Hawaiian species of *Sophora*. It is felt by many authorities that this variation within populations is due, in part, to effective isolating mechanisms, as well as to the differences in environmental factors among habitats in Hawaii.

Sophora was first described as a genus by Linnaeus in Species Plantarum in 1753, and again in 1754. Linnaeus based his classification on examination of six species of *Sophora*, all of which are thought to be native to Asia.

Salisbury (1808) proposed a new genus *Edwardsia*, in which he placed two species, one from New Zealand and *E. chrysophylla*, our endemic species, which was first collected by Dr. Archibald Menzies on Capt. Vancouver's expedition to the island of Hawaii in 1792. Until 1865 *S. chrysophylla* remained in *Edwardsia*, although in one revision of the genus Gray (1854) named the first variety (var. *glabrata Gray*) of the Hawaiian species. B. C. Seeman (1865) transferred *Edwardsia* to a section of the older genus *Sophora* where for the most part it has been left by taxonomists.

Considerable disagreement arose in the 1900's among taxonomists as to the number of species and varieties of *Sophora*. Hillebrand (1888) considered all forms of the tree a single species without so much as a single variety, although he took note in his description the variation between lowland and alpine forms which he characterized by quoting Gray (1854), "These lower forms are nearly glabrate and bear smaller flowers." Other taxonomists believe the tree to be varied enough in its growth forms to justify its being divided into two or more species. E. E. Sherff (1951) regarded the variety *unifoliata* (Rock) Deg. & Sherff to be a true species, and also described what he believed to be another new species, *S. grisea* Deg. & Sherff.

The most recent taxonomic revision of the Hawaiian *Sophora* was done in the 1950's by Alvin K. Chock and published in 1956. It is considered by most Hawaiian taxonomists to be a very thorough taxonomic study of the Hawaiian species, and is the most extensive publication to date on mamane. Chock considered mamane to be a member of the family Leguminosae and the genus *Sophora*. He, as well as St. John (1973) placed all material into a single species, *chrysophylla*, including four subspecies: *chrysophylla*, *circularis* Chock, *glabrata* (Gray) Chock, and *unifoliata* (Rock) Chock, with seven varieties and nine forms being distinguished within the four subspecies.

Chock utilized morphological characteristics that might be useful in distinguishing between the differences found within various populations of Hawaiian *Sophora*. He found that a helpful character in identification to the subspecies level was the shape of the standard, which varies from ovate to elliptic. In categorizing the specimen to the level of variety or form he used the shape and dimensions of the apex and base of the standard, as well as the margin of the wing and keel petals and the degree of pubescence of the leaflets. It should be noted that fruit size and width of wings may vary greatly within samples of specific populations due to invasions of a parasitic fungus that alters their growth and color.

A morphological comparison of pollen grains of several native tree species was carried out by O. H. Selling (1947). Characteristics of mamane pollen, as well as pollen grains from many endemic trees, shrubs and fern spores were presented. Selling's description of mamane pollen was as follows:

> Tricolporate, subprolate, often prolate spheroidal, 22 x 19 μ. Poles and lobes rounded. Colpae long, almost reaching the poles. Pores longitudinal (length about 6 μ). Unless irregularly broken these areas bulge evenly. They are about 1/3 the length of the corresponding colpa. The endexinous thickenings of the polar hemispheres show no marked breaks toward the poles as in other cases. Exine about 1.5 μ thick, light colored, and of minute texture, in which a reticulate pattern can be distinguished under high magnification. This type of pollen appears to be distinct in the Hawaiian flora. It cannot be confused with *Xylosma* although of similar texture and similar general size.

DISTRIBUTION AND COMMUNITY OCCURRENCE

In one of the earliest attempts to describe and classify vegetation in Hawaii, Ripperton and Hosaka (1942) utilized a method of dividing types of vegetation into distinct zones on the basis of climate and occurrence of plant species. The investigators designated five different vegetation zones (A-E), and the general characteristics of each were noted in relation to elevation, climate, topography and soils, as well as species composition.

This early publication serves as a good reference to the distribution and occurrence of *Sophora* in Hawaii. The only zone in which *Sophora chrysophylla* was said to occur was Zone E. According to these two authors the only islands on which Zone E exists are Maui and Hawaii. Three categories of Zone E are distributed as follows: a low elevation phase, E1, extends from 4000 to 7000 feet, and a high elevation phase, E2, exists from 7000 to 10,000 feet. A third phase, E3, is designated for the land area above 10,000 feet. This area encompasses the dry upper slopes of the high mountains, i.e., Haleakala on Maui and Mauna Loa and Mauna Kea on Hawaii. It was noted that rainfall in Zone E is low, generally believed to be between 20 to 40 inches per year. However, Zone E1 frequently receives added moisture due to fog drip. Frosts have been noted at all elevations down to 4000 feet, with snow frequently dotting the tops of peaks above 10,000 feet throughout the year, and especially during the winter months. Subzones E2 and E3, being situated above the maximum rainfall belt, receive maximum amounts of sunlight due to decreased cloud cover.

Much of the area in Zone E, especially in the upper slopes of the older mountains, is characterized by the presence of many cinder cones which have, for the most part, covered the surface of the area with a loose mantle of ash. The texture and consistency of this material varies from coarse gravel to extremely fine ash. Soils of this character are often characterized by low water retention. In portions of the lower phase, E1, where rainfall is relatively abundant, accumulation of some organic matter can be seen. In certain sections of Zone E1, where ash cover is deep and fine textured, plant growth is said to be locally favorable.

Vegetation in the lower elevation phase E1 is said to consist of plateau parkland species and, in drier parts of the zone, mountain parkland types predominate. A typical vegetation pattern exists, characterized by scattered clumps of trees interspersed with small to extensive areas of grassland between the clumps. Ground coverage is sparse, increasing in density proportionately with the depth and moisture retention capabilities of the soil pockets. Dominant trees in the lower phases are koa (*Acacia koa* Gray) and scattered ohia (*Metrosideros collina* (J. R. & G. Forst.) Gray). Grasses are predominantly of the bunch type with a scattering of herbs, shrubs (*Styphelia tameiameiae* (Cham.) F. Muell., etc.) and occasional ferns.

The middle phase, E2, is dominated by the occurrence of mamane and naio, reaching up to approximately 20 feet in height. Grass cover becomes sparse in this zone with shorter growth forms predominating. Vegetation occurring in the high phase, E3, is on almost barren volcanic substrates. Only mosses, lichens, occasional clumps of grass and the silversword (*Argyroxiphium* spp.) are known to this zone.

Ripperton and Hosaka (1942) reported that mamane is found only in

Maui and Hawaii, that its occurrence is common in the lower elevations of Zone E, and that it is an abundant or, more properly, a dominant component of the community in the middle zone, E2, at elevations from 7000 to 10,000 feet.

Hosaka and Ripperton (1944) noted that *Sophora chrysophylla* is also adapted for occurrence in vegetation zones other than E. More specifically, they stated that on the islands of Hawaii, Maui and Kauai, at elevations between 2000 and 4000 feet, where rainfall varies from 40 to 60 inches per year, mamane is likely to be found.

Chock's (1956) revision of *Sophora* remains, to date, one of the most complete listings of distribution of mamane in Hawaii. He stated that it was very common on the island of Hawaii. At present, it is one of the more common endemic trees on the slopes of Mauna Kea and Mauna Loa. It is also known to occur in the lower forests of the Ka'u District, as well as on the slopes of Hualalai from Puu Waawaa nearly to sea level. It was considered by Rock (1913) to be one of the main components of xeric forests at elevations above 3700 feet.

On Maui it is common on the leeward slopes at elevations as low as 1500 feet, and in the crater of Haleakala from 5000 to 10,000 feet. It has also been found in the windward rain forests east of Olinda at 4000 feet.

Mamane is known to occur on the island of Kauai within Kokee State Park at elevations ranging from 3600 to 4000 feet. *Sophora* from Oahu, in both the lee and windward areas of the Waianae range, has also been reported.

Most noticeable among distribution records is the lack of occurrence on the island of Molokai, with the exception of one collection made by Forbes (Chock, 1956) at Puu Kolekole. Collections have been made on Lanai, but disagreement persists as to whether the population on that island was initiated by human planting. Records of occurrence from the islands of Niihau and Kahoolawe are also lacking, but it is presumed that mamane may have inhabited these islands before eradication of their dry forests.

DEVELOPMENT AND REGENERATION

Situated on the upper slopes of Mauna Kea is one of the greatest expanses of dryland scrub-forest in Hawaii. Scattered throughout the 65,000 acres found between 7000 and 10,000 feet are some 45,000 acres of mamane-naio dry forest. Over the course of the last 200 years, many events have occurred that have been instrumental in altering the structure and composition of this ecosystem. Introduction of exotic plant species as well as the release of feral vertebrates, especially sheep and goats, have disturbed the natural patterns of succession and regeneration in this area.

The U. S. Forest Service has initiated studies to investigate methods of seedling propagation and rates of seed germination of mamane in an effort to understand the mechanisms involved in the regeneration of this tree species (Hubbard, Nelson and Scowcroft, 1971). Seeds were collected from several locations on Mauna Kea and sent to the Eastern Tree Seed Laboratory in Macon, Georgia, for treatment aimed at determining successful methods of breaking seed-coat dormancy. Preliminary analysis indicates that the highest rates of germination were achieved when fresh, unstored seed, collected from newly matured pods, was subjected to either mechanical or acid scarification (Scowcroft, pers. comm.).

An investigation of field germination rates of mamane is also being conducted by the U.S. Forest Service at a site adjacent to the headwaters of the Wailuku River at an elevation of approximately 9200 feet on Mauna Kea. Seeds that were scarified, either mechanically by hand sanding or soaking in a solution of sulphuric acid, produced identically high germination percentages. Seeds soaked only in hot water, as well as seeds receiving no treatment to break seed-coat dormancy yielded contrastingly low rates of germination. Depth of sowing also significantly affects the germination and emergence rates of mamane, although the processes by which mamane seeds are buried at optimum depths in nature are not fully understood. The natural agents responsible for burial of seed are probably shifting of soil and sand due to wind and sedimentation. The introduction of feral sheep and goats into regions of mamane forests raises the possibility that seeds could be trampled into the soil by the hooves of these animals. Any benefits these trees may receive from feral ungulates acting as agents of seed dispersal and burial are certainly negated by voracious browsing habits of these mammals.

It has been shown that in certain ecosystems, such as the dry chapparral areas of coastal and inland California, regeneration of some plant species may be enhanced by fire. In an effort to discover if fire might effectively stimulate germination of mamane in areas where grasses are the dominant members of the community, controlled burning of small selected areas on Mauna Kea was initiated by the U.S. Forest Service (Scowcroft, pers. comm.). Results of this experiment were inclusive. No emerging seedlings were observed within any of the burned plots, even after heavy rainfall. It is possible that some seeds may have germinated, only to die before they could be tallied by observers surveying the plots during monthly sampling visits.

One of the most comprehensive evaluations of development and growth patterns of mamane to date has recently been completed by C. van Riper III (1975). van Riper conducted a 1½ year study of the composition and phenology of mamane within the dry forest area, surrounding the Puu Laau sheep station. His study plots were located at three different elevations ranging from 6500 feet to almost 9000 feet on Mauna Kea. van Riper investigated the relationships between tree height and trunk circumference, and found that both height and trunk circumference of mamane increased with elevation. Reproductive success of mamane and naio was also examined. He concluded that "The percentage of young of each species mirror the composition of mature trees at each elevation. At 7500 feet, where almost all trees (92%) are mamane, 26% of the young trees are of this species and only 6% of the young trees are naio. At 7000 feet where 74% of the forest is naio, 18% of all the trees are young naio and only 5% are young mamane." The 6500 feet study area also contained a high percantage of young mamane (20% as compared to 5% young naio). van Riper attributes this high incidence of young mamane to the fact that the sample plots at this elevation were situated in a region of very dense mamane.

It is quite possible that successful regeneration of mamane is severely hampered by the constant browsing pressure exerted by feral goats and sheep. This appears to be the case on the upper slopes of Mauna Kea, at elevations between 5000 and 10,000 feet. Regeneration here is quite low, noticeably at treeline (approximately 10,000 feet). Distinct browse lines can be observed at heights of between three and seven feet on mamane. These browse lines become more apparent as one approaches the tree line, where the major concentrations of sheep currently are found. The particular variety of sheep inhabiting the tree line area of Mauna Kea at present appears to be somewhat sedentary in relation to herd movement. This behavior results in concentrated browsing of small select areas of the mountain (Scowcroft, pers. comm.).

In 1963, wildlife biologists from the Hawaii Division of Fish and Game began to study the effects of grazing in relation to the regenerative capacity of dryland forests, of which mamane is a major constituent. The U. S. Forest Service in cooperation with the Hawaii Division of Fish and Game and the Hawaii Division of Forestry has undertaken a similar venture. The Institute of Pacific Island Forestry and U.S. Forest Service are presently conducting research in an attempt to determine species composition, relative abundance and cover of vegetation in newly erected sheep exclosures on Mauna Kea. The exclosures are to be monitored periodically to ascertain the growth rates of selected mamane sprouts and seedlings. The Hawaii Division of Forestry and Fish and Game, along with the U.S. Forest Service constructed three exclosures in 1972 and another three in 1973 at approximately 9500 feet on Mauna Kea to examine the regeneration patterns of mamane in areas of heavy browsing. The exclosures encompass about 5 acres. A very noticeable difference in vegetation was found within one of the exclosures only 2 months after its construction. Data from the sample plots showed that more than twice as many different plant species were growing inside the exclosure as outside. Approximately 33% of those plants inside the exclosure were endemic, while outside the exclosure native plants comprised somewhat less than 25% of the vegetation.

Overall plant density was almost 4.5 times greater inside the exclosure than outside. The preliminary information provided by this study indicates the potential for regeneration of mamane and other native vegetation when browsing pressure is removed. Data collected from exclosures located in an area of particularly heavy browsing show that seedling and root sprout survival may be greatly enhanced when browsing pressure is removed. The number of seedlings found within the exclosure outnumbered those found outside by a ratio of almost 50:1. Some 600 root sprouts were counted inside the exclosure, but no root sprouts were tallied outside the exclosure. Data from these exclosure studies will have to be analized carefully over a longer period, but preliminary indications suggest that grazing of dryland forests by goats and sheep contribute substantially to the lack of regeneration of Hawaiian *Sophora*.

While the presence of feral goats and sheep on Mauna Kea plays an important role in the inhibition of successful reproduction of mamane, the processes involved in regeneration of this tree are many-faceted. Environmental stress at elevations above 6000 feet are great and surely contribute to the mortality rate of young mamane. Low rainfall coupled with extreme fluctuations of temperature and other climatic conditions, as well as disease, certainly influence the survival chances of this tree species. A great deal more research is needed in order to understand better the events which control the regeneration of our Hawaiian *Sophora*.

PHENOLOGY

The timing of biological events and the relationships of those events to seasonal climatic changes are not always easily observed in tropical environments due to the uniform nature of climatic variables. This situation dictates that certain parameters normally used as indices of phenological (time-related) occurrences be modified to give an accurate account of the seasonal biological changes occurring within Hawaiian tree species.

Dr. C. H. Lamoureux is presently conducting a study designed to determine the nature of seasonal changes in *Sophora* and other native plants occurring at various locations on Mauna Loa. In a preliminary report he (1973) noted some of the difficulties in obtaining a clear picture of phenological events. Patterns of flowering and seasonal changes in vegetative flushing remain obscure. *Sophora* is thought to exhibit bimodal flowering patterns with peak flowering occurring during the winter at elevations from 4000 to 6700 feet, and with intermittent flowering occurring year round at elevations of 5100 and 6700 feet. Vegetative flushing is highest in spring and summer months with a peak occurring in the summer at 5100 and 6700 feet. Peak flushing was noted at 4000 and 6000 feet during the spring with a recurrence of heavy flushing seen in the fall. Populations of *Sophora* at the 3000-foot level showed no distinct peaks for either vegetative flushing or flowering during the period they were studied. Lamoureux also observed that ripe fruits may remain attached to the tree for up to a year. Seeds appear to fall from the pods intermittently throughout the year, although they do so mostly during the spring.

Circumference measurements of *Sophora* were also obtained in this study, and showed patterns of growth that, in most cases, could not be directly correlated with rainfall.

The relationships between environmental factors and the staging of biological events in *Sophora* remain unclear. It is hoped that continuation of this research effort will solve many of the enigmas of mamane phenology.

CONCLUDING REMARKS

A thorough ecological evaluation of many endemic Hawaiian plant species is difficult to conduct, due to the fact that so little information has been gathered on many species.

Sophora chrysophylla has been studied by many researchers over the past 200 years, yet surprisingly little information appears in the literature. Most notably absent are physiological studies of most Hawaiian tree species, including *Sophora*. Moreover, research has been published on the chemotaxonomic relationships of Hawaiian *Sophora*, and very little information has been reported on the derivation and evolutionary history of mamane.

The objective of this paper was to present some new information about mamane, and to summarize the important aspects of previous research efforts.

ACKNOWLEDGEMENTS

I thank Mr. Paul Scowcroft of the U.S. Forest Service for the information provided concerning regeneration studies being conducted on Mauna Kea, and for his help in compilation and preparation of this manuscript. I also thank Dr. Sheila Conant of the University of Hawaii Department of Botany, for her help and encouragement in the preparation and revision of this paper.

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NOTES FROM THE LYON ARBORETUM - I. INTRODUCTION

> Arboretum, är.bo.rē'.tum, n. (L.) A place in which a collection of different trees and shrubs is cultivated for scientific or educational purposes. (Webster Encyclopedic Dictionary.)

The Harold L. Lyon Arboretum is a research and instructional facility of the University of Hawaii. It covers 124 acres at the head of Manoa Valley, about 2.5 miles north from the Manoa Campus of the University, and was established in 1918 by the Hawaiian Sugar Planters' Association to demonstrate the restoration of rainforest vegetation and to collect plants of potential economic value. Since its presentation to the University of Hawaii in 1953, the Lyon Arboretum has become an important facility for research and instruction in botany, zoology, agriculture, phytochemistry, medicine and pharmacology. Until 1953, the arboretum was known as the Manoa Arboretum. It was renamed the Harold L. Lyon Arboretum in honor of Dr. Harold Lloyd Lyon, who served as director of the facility for 23 years.

Over the years, Dr. Lyon and his associates introduced and cultivated thousands of species of trees and shrubs at the arboretum. During the first 20 years, a vigorous arboretum was established where there once was a cow pasture surrounded by a few 'ohia and guavas. In 40 years, a fine forest was established; today, less than 60 years after the first plants were planted, the arboretum is a veritable jungle.

Many of the early introductions did not survive, and even today, not all of the introductions succeed. There are presently about 4000 accessions, representing some 190 families, 970 genera and 1850 taxa. In addition, there are about 800 undetermined species. The arboretum is internationally known for its fine collection of palms, figs, taro and Hawaiian endemics.

The arboretum engages in seed and plant exchanges with individuals and institutions throughout the world. All of the propagation material received or sent out is cleared through quarantine authorities. These exchange programs are tempered by the realization that some of the imports may be noxious.

Several families are well known for their weedy species; members of these families are planted in areas where they can be closely watched. For instance, only two species (and only three individual plants) of the Melastomataceae have been planted in the upper sections, while eight species are being watched carefully in the lower lawn areas. Two species in other families already have been destroyed.

STAFF

Yoneo Sagawa, Director; Robert T. Hirano, Assistant Researcher; Derral R.

Herbst, Assistant Researcher; Kenneth M. Nagata, Research Associate; Sharon S. Ishikawa, Research Associate; Glen E. Spence, Jr., Technician; Donald Anderson, Technician (Retired); Beatrice Krauss, Research Affiliate; Dorothy Niimoto, Research Affiliate.

Kenneth M. Nagata
Research Associate
Harold L. Lyon Arboretum

OBSERVATIONS ON *FISSIDENS CRUMII* (BRYOPSIDA: FISSIDENTACEAE), AN ENDEMIC HAWAIIAN SPECIES

When first described, *Fissidens crumii* Hoe (Hoe 1972) was known only from scanty, sterile material growing on crushed corralline rocks at the base of the Castle Trail in Punaluu Valley, Oahu. A subsequent report (Hoe 1974) indicated a wider distribution for the species, with all collections from low elevations, usually on very shaded, wet, trampled soil; all were from Oahu and were sterile.

Recently, two further collections (Hoe 3330.0, Smith, sn [Hoe Accn. No. 74-1338]) have become available; they are significant because they are the first found with filamentous gemmae and archegonia. Therefore, the following modified description will better characterize the taxon:

> Apparently dioecious. Small, green plants about 3 mm tall; stems unbranched. Leaves in 7-10 pairs, small below, progressively larger toward the stem tip, uppermost leaves about 1 X 0.25 mm, slightly arched and sinuate when dry, oblong-lanceolate, acute; margins smooth below and bordered with about 2-3 rows of narrow, elongate, smooth cells, near the apex serrulate, unbordered, dorsal lamina narrowed toward base; costa greenish-yellow to light golden to red, very slightly sinuate, ending about 3/4 of way from insertion; upper leaf cells flaccid and irregularly elongate-hexagonal, 30-40 X 15-18 μ, thin walled. Filamentous gemmae sometimes produced in abundance, arising from branched axillary stalks; the gemmae smooth-walled, green, unbranched, easily detached, of varying length and composed of between 3-20 cells, with the cells toward the base wider than those toward the apex. Archegonia usually 2-5, terminal; perichaetial leaves not or scarcely differentiated. Perigonia and sporophytes not seen.

Fissidens crumii belongs to the Sect. *Reticularia*, characterized by the thin-walled, elongate-hexagonal nature of the leaf cells. A perusal of the literature indicates that whenever such information is given, the species are dioecious and that sporophytes are very rare or unknown; Gangulee (1971) described and figured filamentous, axillary gemmae for an

Indian species. Correspondence with Drs. Z. Iwatsuki and R. Pursell also indicates the presence of this filamentous type of gemmae in some Asian and tropical American representatives of the section.

It seems apparent, then, that many species of *Fissidens*, Section *Reticularia*, are very rarely or never spore-producing and that asexual reproduction by means of axillary gemmae is the usual method of dispersal. *Fissidens crumii* is no exception.

I thank Dr. C. W. Smith for making available for study his collection of Fissidens crumii.

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DR. GEORGE RUSSELL

A special guest at the University of Hawaii during May was Dr. George Russell, invited by Dr. Maxwell S. Doty to survey the structural aspects of algal intertidal communities and to discuss interspecific competition, variations in response of algae to heavy metals, and the taxonomy of Phaeophyta.

Dr. Russell (Ph.D., University of St. Andrews, Scotland) is senior lecturer at the University of Liverpool (England), a position formerly held by Dr. Peter Dixon.

En route to Hawaii, Dr. Russell visited the Scripps Institute of Oceanography as a guest of Drs. Ralph Lewin and Joan Stewart. There, he gave two lectures and visited the large *Macrocystis* (kelp) beds.

Although he has been on several expeditions to the tropics (Diego Garcia, etc.) this thin, red-bearded, quickly sunburned Scot found his first visit to the United States and Hawaii relaxing. He adapted to foreign surroundings successfully as revealed when he used *TheBus* from the University of Hawaii to Magic Island without complications!

There are four things that impressed him in Hawaii: the Hawaii Institute of Marine Biology, the Naval Undersea Center, the lack of easily obtained indigenous higher plant species and the Big Mac hamburger!

Dennis J. Russell
Department of Botany
University of Hawaii - Manoa

NEWS AND NOTES

Dr. & Mrs. Albert C. Smith have arrived in Honolulu where they expect to spend most of the summer. Dr. Smith, who is Ray Ethan Torrey Professor of Botany at the University of Massachusetts, will be working on his Flora of Fiji at the Bishop Museum and the University of Hawaii Department of Botany. He is accompanied by two of his students, *Miss Judith E. Haas* and *Mr. Steven P. Darwin.* Judy is engaged in a revision of the genus *Pittosporum* in the Pacific while Steve is interested in certain problems in the Rubiaceae of the same region....*Frank Wightman,* Professor of Botany at Carleton (Ottawa) University, recently spoke to the Botany Research Seminar on the "Occurrence and biosynthesis of a new natural auxin in higher plants." Dr. Wightman has worked on the metabolism and synthesis of auxins for twenty years and has recently identified an auxin-active compound, other than indole-3-acetic acid, in higher plants.

CALENDAR OF UPCOMING EVENT

? November	Bot. Soc. plant donation

MINUTES OF THE REGULAR MEETING OF APRIL 7, 1975

The meeting was called to order at 7:30 p.m. by the president, Derral Herbst. The minutes of the previous regular meeting were read and approved. There were 40 members and 31 guests in attendance.

In new business, Dr. Herbst announced Dr. Hartt's recommendation to donate income from the Marie Neal Memorial Trust Fund to support botanical gardens. After some discussion, Sheila Conant suggested that some of the money could be used for other special projects such as supporting a graduate student to prepare an index of the Society's newsletters. It was moved and seconded to advise the Trustees of the Marie Neal Fund to contribute $100 to the Pacific Tropical Botanic Garden, $100 to the Lyon Arboretum, and $25 to the Foster Botanic Garden. The motion failed. There was further discussion. Dr. Lamoureux, speaking as a trustee, asked for advice on whether the Society wanted to give a set amount each year or to decide each year how much to spend for special projects.

Richard Becker proposed a motion to recommend that the Trustees use income from the Neal Fund for special projects, the first such special project to be the creation of an index for the *Newsletter*. After further discussion, Mr. Becker amended his motion to include other special projects such as donations to Lyon Arboretum, Foster Garden and the Pacific Tropical Botanic Garden. The motion passed as amended.

It was announced that the publication "Rare and endangered species of Hawaiian vascular plants" by Society members F. R. Fosberg and D. R. Herbst was available in *Allertonia.*

Steve Montgomery suggested that the Society might consider a special project on the order of the Audubon Society's recent poster of native birds.

It was announced that the Society is planning a foray to Kaena Point for late June or early July.

The vice president, Sheila Conant, introduced the guest singers, Mike and Lorna McClellan who entertained us with songs about plants and animals. Sheila then introduced Mr. Art Whistler, a graduate student in botany, who presented a slide-talk on "People, places and plants of Samoa."

The meeting adjourned to the lobby for refreshments.

Jean Maka, Secretary

MINUTES OF THE REGULAR MEETING OF MAY 12, 1975

JOINT MEETING WITH THE HAWAII AUDUBON SOCIETY

The president, Derral Herbst, called the meeting to order at 7:40 p.m. A motion to suspend the business meeting was passed unanimously.

After a brief business meeting of the Audubon Society, the Hawaiian Botanical Society vice president, Sheila Conant, introduced the speaker of the evening, Mr. Bill Mull, who gave an illustrated talk on "Some Hawaiian invertebrates: A pictorial essay and commentary."

Jean Maka, Secretary

UH RESEARCH ACTIVITIES

From time to time we are publishing a list of the research activities and the persons involved in the botanical sciences at the University of Hawaii. This report lists ongoing algal research projects and some which were recently completed.

Mr. Bruce Allender is preparing his thesis on the ecological aspects of some Hawaiian species of the Dictyotales with special reference to *Padina japonica* Yamada.

Mr. Mitchell Hoyle is working on the biology of *Gracilaria*, emphasizing the ecology and effects of sewage pollution on Hawaiian species.

Mr. Jeffery Hunt is investigating the roles of coralline algae in the reformation of reefs.

Mr. James Kubus is measuring the surface area of algae by the use of dyes as a prelude to studies on the effect of water movement on the morphology of *Gracilaria*.

Mr. William Magruder is beginning a study of the biology and distribution of *Ahnfeltia* (Rhodophyta, Gigartinales).

Dr. Keto Mshigeni completed his Ph.D. dissertation on the biology and ecology of selected Hawaiian Hypneaceae (Rhodophyta, Gigartinales). This work included studies on the systematics of the group and the properties of a phycocolloid of *Hypnea* sp.

Mr. Dennis Russell is working on introduced species of macro-benthic algae in Hawaii. He is investigating competition of the exotics, particularly *Acanthophora spicifera*, with native species.

Dr. Bernabé Santelices recently completed his Ph.D. dissertation on an ecological study of Hawaiian Gelidiales (Rhodophyta). The study also included investigations on the morphological variation in *Pterocladia caerulescens*, a taxonomic review of the Hawaiian Gelidiales and notes on their mass culture.

Ms. Diana Wong is studying the food organisms of shrimps in myxohaline ponds.

SPECIAL THANKS to Lucy Cranwell Smith (2040 East Drachman Street, Tucson) for her generous monetary gift to the Society.

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
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Newsletter Hawaiian Botanical Society

Contents

VOLUME 14 NUMBER 4 OCTOBER 1975

THE PROPAGATION OF HAWAIIAN ENDANGERED SPECIES
by K. R. Woolliams .59

CONSERVATION COLUMN
by R. Gay 69

RECENT PACIFIC PUBLICATIONS - 2
by C. H. Lamoureux 69

BRIEF REPORTS AND NOTES

SOCIETY BUSINESS...58; *Degener & Degener* - REVIEW..78; *Nagata* - LYON ARBORETUM NOTES II...80; *Ishikawa* - LYON ARBORETUM ASSN...80; *Conant* - TESTIMONY...81; *Lamoureux* - H. ST. JOHN...82; *Smith* - MUSHROOMS...84; *Lamoureux* - 13TH PACIFIC SCIENCE CONGRESS ....85; CALENDAR....90; NAMES AND NOTES...90.

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE REGULAR MEETING OF JUNE 3, 1975

The meeting was called to order by the president, Derral Herbst, at 7:35 pm. The minutes of the two previous regular meetings were read and approved. There were 18 members and 8 guests in attendance.

The president announced the winners of the botanical exhibits at the Science Fair. He said that he had copies of Marie Neal's book, *In Gardens of Hawaii*, presented to the winners. A motion was passed to approve the president's action on behalf of the Society.

The senior selected as most likely to reflect credit on botany was Jane H. Thronis. A motion was passed to present a book to Ms. Thronis, the title being left to the discretion of the Society's president.

Upcoming events of interest were announced.

The vice-president, Sheila Conant, introduced the speaker for the evening, Mr. Steven Sato from the U.S.D.A. Plant Quarantine who spoke on current plant quarantine regulations.

The meeting was adjourned to refreshments at 9 pm.

Jean Maka, Secretary

The Botanical Society files have accumulated copies of several items of interest to our readers. Requests for any of these (limit: 1 copy of each item) should be addressed to *Ms. Lani Stemmermann, Circulation Manager, The Hawaiian Botanical Society, Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822* and be accompanied by a single *self-addressed mailing label* and a 10¢ stamp for each item desired. Requests will be honored as long as supplies are available.

45 copies. 25th Anniversary issue (1924-1949) of the Botanical Society.
30 copies. C. E. Hartt. 1937. The Hawaiian Botanical Society. Paradise of the Pacific 49(2).
200 copies. H. L. Lyon. 1956. Honolulu can have a botanical garden. Univ. Hawaii Occasional Paper 63.
100 copies. 50th Anniversary issue of the Botanical Society.

Volume 14 Number 3 was mailed July 25, 1975.

THE PROPAGATION OF HAWAIIAN ENDANGERED SPECIES*

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Page
INTRODUCTION 59
REASONS FOR THE PRESENT SITUATION. 60
AIMS OF CULTIVATION. 60
COLLECTION OF MATERIAL FOR CULTIVATION 61
PROPAGATION FACILITIES 62
PROPAGATION TECHNIQUES 63
AFTER CARE 64
EXAMPLES OF SUCCESSES AND FAILURES 65
LITERATURE CITED 68

INTRODUCTION

The following summary of the state of the Hawaiian flora, will serve to show the urgent necessity of its preservation:

Total Number of Taxa: 2734[1] (Endemic: 2668, Indigenous: 66)

Endangered .... 800[2]
Status Unknown 518
Extinct 273

By regarding 'status uncertain' as endangered until more is known, we have a total of 1318 - or almost 50% of the known species either under stress or facing extinction - a sad state indeed.

To complicate matters further, we do not know just how many species are endemic to Hawaii. The above figure represents a summary of present knowledge though Degener[3] suggest there may be as many as 20,000 species!

---

* Text of address delivered at the recent conference on "The function of living plant collections in conservation and in conservation oriented research and public education" (Kew Conservation Conference) held September 2-6, 1975 at the Royal Botanical Gardens, Kew, under the sponsorship of the NATO Eco-Sciences Panel.

REASONS FOR THE PRESENT SITUATION

Inevitably man is largely to blame through his destruction of habitats over a long period of time. While it is true that State and National parks are providing valuable protection to many areas, the majority of the remaining Hawaiian flora is under considerable stress, mainly due to the depredations of feral goats, pigs and sheep and the rapid spread of destructive introduced weeds such as *Passiflora mollissima, Rubus penetrans, Rubus ellipticus* and *Clidemia hirta.* That these can be controlled but are not, due to political and economic pressures, pinpoints the plight of Hawaii's flora today. A case in point is a recent report in a local newspaper that goat hunting on parts of Kauai would be banned during 1975 to "allow populations to increase to satisfactory hunting levels." Meanwhile the long battle to prevent the introduction of Axis deer on to the island of Hawaii is far from over.

Not all plants are facing extinction because of man however. In a flora which has evolved in very specific habitats, it is inevitable that small changes in factors as climate can have marked effects.

In addition, there is little doubt that some species are simply facing the "end of the evolutionary line" and are naturally becoming extinct, as species have for millions of years.

During the last 20 years, work on the cultivation of Hawaiian endemics has been carried out by a few people in Hawaii, though few records of propagation have been kept. Obata[4-6] published 2 articles on his experiences and plants of several species are in cultivation at Lyon Arboretum[7] and the Honolulu Botanic Garden[8].

AIMS OF CULTIVATION

While there is no doubt that in most cases habitat conservation is the most successful method of species conservation, in the absence of such, preservation through cultivation becomes essential.

Our aims in this work are:

a) preservation through cultivation in botanical collections and amassing data on cultivation techniques,

b) re-introduction into the wild, under scientific control, and

c) popularizing the more ornamental species for home and landscape use.

Another important aspect of our work is education; through tours, displays and publicity we hope to spread knowledge of the importance of preserving the world's flora and fauna.

COLLECTION OF MATERIAL FOR CULTIVATION

We have found that it is usually easier to propagate from plants in cultivation than from material brought in from the wild. The reason for this is that proper selection of seeds or vegetative material can be made. When collecting in the wild there is often little choice of vegetative material and fruit in the correct stage for harvesting is not always available. In addition, there is an inevitable 'shock' caused to vegetative material by the delay in getting the material to the propagating area plus introducing it into a different microclimate. Where rare species are concerned, one has to balance the chances of success with such material against the possible effects on the wild population of removing it. This is especially true when seedlings are taken from the wild as results are often unpredictable.

For these reasons it is useful to grow a wide range of species, including commoner species, in order to get knowledge and experience to help cope with problems which might arise with the rarer species.

When expeditions are going to collect living material over a period of time, it is important to devise a method of keeping them fresh until arrival at the nursery. A satisfactory method is to prepare cuttings and plants at base camp, wrapping base areas in moist sphagnum moss and enclosing each in a tightly tied plastic bag. The aerial protions are left exposed. These are then laid in rows, not more than two deep, in large plastic bags with the top folded over. Conditions in this plastic 'tent' are controlled daily by opening and closing the bag. When the inside condensation is too great the bag is turned inside out. In this way cuttings and plants can be kept in good condition for up to three weeks. On short trips, it is enough to carry everything in a large plastic bag.

When taking cuttings it is good to get a wide variety of wood; with seeds, unripe fruit of mature size will often ripen if they are placed in a plastic bag (with a few holes in it) and hung up out of direct sun. After ripening, the seeds can be sown in the usual way.

It is important that horticulturists become familiar with a wide range of habitat types by collecting widely themselves. A disadvantage of course is that they will not always be familiar with the species especially in such a diverse flora as that of Hawaii.

If persons other than horticulturists are collecting, it is essential that information which can help successful cultivation is noted and accompany the material. Such information as percent of light, soil drainage, water requirements and air-movement can sometimes be of immense value. When working "blind" the chances for success are drastically reduced. For example, to receive cuttings "collected E. Maui, elev. 2000 ft.", does not really help very much!

Obviously the ideal is for horticulturists and botanists to work closely together. In this respect, we at Waimea consider ourselves exceptionally fortunate in having Dr. Derral Herbst as our honorary consultant for Hawaiian flora: Dr. Herbst knows the plants and appreciates the needs of the horticulturists.

PROPAGATION FACILITIES

At this stage it may be useful to try to describe the propagation facilities at Waimea.

The area is well protected as it is located at the foot of a steep bluff which bisects the valley; however, there is plenty of air movement.

We believe it is essential to keep the propagation area small, so that a constant watch can be kept on all plants. To draw attention to endangered species, a red line is made on all "lead" labels, i.e., the first label in the row. This is a 10 inch plastic label.

Seed House.

This is an insect-proof house with a solid roof of green corrugated plastic with filtered light and screened sides. Watering is by manually operated mist. The bench is of heavy wire mesh and one portion has a heating mat with temperature controlled by thermostat. The floor is of concrete which aids hygiene.

Cutting Beds.

Vegetative propagation is mainly done in a long bed built of concrete blocks on a concrete floor base under 63% shade cloth. This bed has 6 divisions of pure coarse sand or cinder and peat, over a layer of coarse gravel, and with or without heating cables. Mist is operated by an 'electronic leaf'. Hardening-off after potting and prevention of transplant shock is provided on benches with time-clock controlled mist. A solid roof for rain protection, covered with roll-up shade cloth provides either 10 or 73% shade. In order to provide rain protection or additional shade, mobile shelters can be rolled over any bench.

The main benches for growing plants are either under 30%, 55%, 63% or 70% shade-cloth to provide a wide range of conditions. All benches are of slotted angle-iron with slats on top; coarse gravel is below. Paths are of concrete.

Set in the roof of the propagation area are adjustable manually operated nozzles which can provide mist for humidity increase or can be used for watering in the summer in long dry periods.

All floors of the propagation area are treated with a sealant and washed weekly.

PROPAGATION TECHNIQUES

Seeds.

We usually hot-water treat or file hard seeds and we are just beginning to experiment with gibberellic acid soakings.

Sowing is usually in our standard 2 parts soil, 1 part peat (medium), ½ part perlite, ¼ part black cinder; the soil is a mature mixture of chicken manure, soil and shredded leaves and chips, partially sterilized at 160 F.

Where practical, seeds are counted when sown and first germination is recorded. All information is noted on the back of the lead label.

We are beginning trials with sterilized and unsterilized soil in cases where germination is known to be rare, as almost nothing is known of possible mycorrhizal or other relationships. Another unknown is to what extent an after-ripening period is needed before germination can take place.

On several occasions, seeds from the same plants in the wild, apparently fully ripe, consistently failed to germinate under any of our treatments. Then for no apparent reason, another harvest would give an excellent germination! Just why this should be is not known, but more work needs to be done on this. Flask culture (i.e. abscission of embryo) should give interesting results. On other occasions, a first sowing yielded no results but a second sowing a few months later, using surplus seeds from the refrigerator, produced a few seedlings!

Green *Pritchardia* seeds, providing they are of mature size, will usually germinate. The time needed for germination appears to be longer than for fully ripe seeds - as may be expected. Green *Pittosporum* fruit will often open in a plastic bag and after sowing in the usual way may germinate.

There is no doubt that we have a great deal to learn about the physiology of Hawaiian seeds. From the practical point of view we do not yet have enough data recorded to draw any meaningful conclusions.

A final word while on this subject: I know of no-one who has successfully germinated "Pukiawe" - *Styphelia tameiameiae* - yet this plant is one of the commonest low to high elevation plants, and seedlings are abundant in the wild. Possibly the fruit passes through a bird...so we are now considering using a mynah bird as part of our propagation program!

Cuttings.

The cutting-bed is under 63% shade, as full sun is too strong under our conditions of long hours of clear skies, especially in summer.

A large number of Hawaiian plants grow in shady conditions and results indicated that cuttings from such plants root better when approximately the same amount of shade is given during propagation. Rooted plants are more tolerant of variation.

Use of rooting hormones containing Thiram fungicide is standard treatment but trials with and without hormones are often made. On one or two occasions, hormone treatment seems to have had detrimental results, but this has not been positively established and results are not consistent.

Where cuttings take a long time to root, liquid fertilizer is watered on every 2 or 3 weeks. More trials on the use of this are planned.

When the species is rare, every piece of available material is used and many kinds of cuttings are made, usually with inconsistent results. On balance, however, heel cuttings do best for most species.

When rooted, the plants are potted into the standard potting mix of 3 parts soil (unsterilized), 1 part cinder, ½ part perlite; however, this is varied when necessary.

The pots are placed under clock-controlled mist and occasionally Captan or Tri-copper sulphate drenches are used as precautions against damping and stem rot (*Pythium*), which are prevalent in our area.

AFTER CARE

As might be expected, plants from elevations of, e.g., 3000 feet, do not do too well at or near sea level, and to date no botanical garden in the islands has a high elevation site. However, we have found that if the plants are given about 10-20% higher shade than they get normally, to reduce leaf temperature, and plenty of aeration is provided, they can be induced to survive for quite a long time.

At Waimea, the arboretum site goes from sea-level to 1000 feet and rainfall from 25" to over 100" per annum. Although a site at 3000 feet would be a great advantage, we feel that even at 1000 feet there is a good possibility of several of the higher elevation plants from wetter areas growing quite well. Those from drier areas may grow at lower elevations if a little extra shade is given.

The problem is that many Hawaiian endemics are unpredictable from the time they arrive at the propagation area until they are flowering and fruiting months later. The main reasons for this are nematodes and fungus diseases, especially *Pythium* stem rot, which appear to be more prevalent in the lower elevations.

Obviously this has to be taken into consideration, especially with dry-land plants, e.g., *Sesbania* species, where continuously damp soils aid the rapid spread of soil fungi. By using sand and gravel mixed with the soil and layers of sand or gravel on top of the soil, plus occasional applications of Captan and nemacides, some degree of control can be obtained. Drip irrigation shows promise also, as the soil surface can be kept relatively dry. This is especially good for strand plants, as in the wild the neck of the plant is naturally almost always dry, while the roots never are.

For the more moisture-loving species, a micro-climate which is shady, cool, humid and has mist nozzles to try to imitate the "cloud-drip" found in many habitats, is being constructed. No doubt much experimentation will be required. It is hoped that many of the rain forest *Peperomia* species, epiphytic ferns and lobeliads can be grown in such an area.

Hawaiian plants are very susceptible to damage by insecticides and fungicides and will often die more rapidly through their use than without! The same is true to a lesser extent, with fertilizers. In the former case, it is necessary to test on a few plants first, while in the latter case the purely organic "soil conditioner" type fertilizers or liquid feeding, produce the best results.

To sum up, perseverance is necessary throughout and large numbers of plants should be grown where possible, to allow for sudden losses.

EXAMPLES OF SUCCESSES AND FAILURES

Hibiscus.

All the endemic Hibiscus are easy to grow, either from seeds or cuttings (though *H. kahilii* is sometimes difficult to root). As most of them are floriferous and attractive their future seems assured, although they not yet widely cultivated.

The seeds respond well to a warm water soak prior to sowing, while the use of rooting hormones is a definite advantage for cuttings. The higher elevation species do quite well in the lowlands and several of the low elevations species, e.g., *H. rockii* which is restricted to a single roadside colony on Kauai, grow better in cultivation and respond well to feeding.

Argyroxiphium--The "Silverswords."

These will not succeed at low elevations except in very special circumstances and with a lot of care, especially with watering. As a guide, it might be said that if *Protea* can be grown, so can silverswords. A very porous soil is needed, little water (though the plants receive much "cloud drip" in the wild) and an almost continuous breeze. *A. kauense* comes from a naturally moister area than *A. sandwicense*, the better known species, but is still a high elevation plant. In the low elevation a cooled house with fan is the best method of cultivation.

A. virescens, the Maui Greensword is a high elevation species from rain forest habitat and appears to be less particular in its requirements. Good drainage is essential and 10-20% shade to keep off the extreme heat of the sun is beneficial.

Pritchardia.

An interesting project during the last year has been the mapping of known colonies of *Pritchardia,* the only Hawaiian genus of palms. This group is taxonomically very confused and many of them are highly endangered. *P. monroi,* for example, is known from only one (possibly 2) plants on Molokai. Plans are being made to gather quantities of seed of this species, through the help of the Hawaii State Department of Fish and Game. As rats eat the seeds of all pritchardias, netting of the inflorescences may become necessary. *Pritchardia kaalae* and its variety *minima* are found only as small colonies on Kaala, Oahu. These are now in cultivation.

Other *Pritchardia* often grow on inaccessible slopes or tiny islets with sheer cliffs, often with no landing place for a boat. While we can guess at their affinities, we cannot be sure and we hope to raise funds for a helicopter for collecting from some of these difficult areas.

As mentioned before, *Pritchardia* are not difficult to grow and green fruit sown direct or allowed to ripen in a plastic bag prior to sowing usually germinate. Although most of the species are either coastal plants receiving much salt spray, or high elevation plants often from windswept mountain ridges, they do not appear to "need" these habitats and will grow well in the lower elevation in cultivation.

P. remota, from Nihoa Island, is known from 2 valleys there. In the wild many of the seeds are "sown" by the shearwaters when they burrow in the sand to make their tunnels. Fortunately this also is not necessary.

Sesbania tomentosa.

This species is of special interest because it is found as several island forms: that on Hawaii Island with prostrate branches and orange-pink flowers and the prostrate Molokai form with red flowers, being the rarest and in need of immediate protection. The Molokai tree form, *forma arborea,* is also extremely rare and endangered.

By hot water treating the seeds prior to sowing and then repeating this over and over again for those that do not germinate, almost 90% germination has been achieved over a period of several months, even with seeds over 2 years old.

As far as cultivation is concerned, the plants are very susceptible to *Pythium* attacks, but with attention will flower and fruit well. If planted in very dry localities or by having young plants constantly ready for planting, it can possibly be kept in cultivation. It is too bad that it is so difficult, as with its silvery foliage and attractive flowers, the prostrate forms would make excellent ground cover plants. The Oahu Island form is of easier cultivation and may well find its place in landscape work in the future.

Camphusia glabra.

This beautiful plant only causes frustration: cuttings do not root and seeds do not grow!

This plant may be likened to a yellow-flowered *Scaevola,* and is often still known as such. If the secret of its cultivation can be found, this would be a most desirable plant for cultivation.

Only once did I get seeds to germinate: over a period of 3 years, after several sowings involving over 100 seeds, using all techniques that I could think of, 2 seedlings unexpectedly germinated. Ironically, no special treatment was used on the seeds. These seedlings refused to grow larger than 2" and after 3 months suddenly died. Cuttings have never shown any signs of rooting.

Currently seeds are being treated with Gibberellic acid, but with no results to date. Our next attempt will be to graft it onto stocks of the common "Naupaka," *Scaevola taccada.* As with all Hawaiian plants which "cannot be grown," there has to be a way, as occasional seedlings are still to be found in the wild!

Hibiscadelphus hualalaiensis and *H. giffardianus.*

Generally speaking, these members of the Malvaceae are of easy culture in the propagation stages. Seeds usually grow well, though cuttings have not rooted for me. It is important to use fresh seeds.

Being mid-elevation plants, perhaps the only way to grow them successfully in the lower elevations is to grow them under about 25% shade.

Hibiscadelphus distans.

This species, recently discovered in Waimea Valley, Kauai, by Dr. Herbst is a dryland, "low" elevation plant. To date it has proved to be of easy cultivation from seeds and we have a plant flowering that is less than 3 years old from seed. While not of spectacular beauty, it is of considerable interest as the flowers are greenish and the young leaves are an attractive silver color.

Kokia drynarioides and *K. kauaiensis.*

These are similar to *Hibiscadelphus hualalaiensis* in that they are of easy cultivation from seed and can probably be grown in the lower elevations as they grow fully exposed in the wild at about 1500-1900 feet elevation.

Kokia cookei.

Reduced to a single plant in cultivation on Molokai Island, it has been saved from extinction by the Cooke family. Apparently short-lived, it is from quite a dry area of Molokai, but the remaining plant is in a moister area and the plant is declining. Fresh seeds germinate readily and at one time I had 8 plants growing on Kauai. On a recent visit I noticed that they apparently had died. The problem is getting fresh seeds and we are now working on getting the owner to send over fruit as they mature. We also plan to air layer the plant. Cuttings under mist and with heating cables fail to do more than make a little callus and in the past have gradually died out.

It will be sad to lose this species; which has barely managed to stave off extinction; the flowers are an attractive red and as a small tree it is considerably attractive.

Euphorbia degeneri.

Of the several endemic species of *Euphorbia* which are endangered, this one is perhaps the strangest because of its ease of cultivation. This depleted species is 'endangered' because it grows on prime hotel and park sites. In the wild it lives on extremely poor soil or in pure sand, while seedlings brought into cultivation grow with an ease which is amazing! Cuttings root readily and seeds will germinate. The form of the plant is considerably different in cultivation, due to the abundance of rapid growth that it makes.

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CONSERVATION COLUMN

Ruth Gay
Department of Botany
University of Hawaii - Manoa

Exemption Lists

Departments in the State Government have prepared lists of actions having minimal effect on the environment, and are presenting these lists to the Environmental Quality Commission for approval as exemptions from Environmental Impact Statements or Negative Declarations. The Conservation Committee of the Hawaiian Botanical Society submitted written testimony to the Commission regarding the proposed exemption list for the Department of Land and Natural Resources. We recommended revision or deletion of those actions which apparently could result in substantial impact. Under the class "Research and Testing" we suggested replacing the general terms "studies, collection and propagation" with specific descriptions of those studies, collections and propagations that would result in no major disturbance. Likewise, we asked for the addition of specific descriptions to proposed exemptions for "operations on wildlife habitats and forest stands" and "revegetation of burned or eroded areas."

Forestry Conference

The 17th Annual Forestry Conference was held at the Waiakea Resort Village in Hilo on October 23 and 24. Under the theme "The Impact of Government on Forestry Practices in Hawaii" the program covered aspects of the endangered species act, environmental regulations and forest products in Hawaii. The list of speakers was headed by John McGuire, Chief of the U.S. Forest Service; Harold O'Connor, Deputy Director of the U.S. Fish and Wildlife Service; and Lieutenant Governor Nelson Doi. Ron Hurov, past president of the Hawaiian Botanical Society, presented a paper on minor forest products.

RECENT PACIFIC PUBLICATIONS - 2.

C. H. Lamoureux
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AMERSON, A. B., Jr., R. B. Clapp and W. O. Wertz II. 1974. The natural history of Pearl and Hermes Reef, Northwestern Hawaiian Islands. Atoll Res. Bull. 174: 1-306.---Compilation of previous studies and abundant new observations. Emphasis on birds, with sections on geology, climate, history, scientific visits, vegetation (including vegetation maps and a species list complete with specimen citations), mammals and reptiles. (NOTE: on p. 38 it is stated that Lamoureux collected on Pearl and Hermes on a date unknown, and in appendix table 3, pp. 281-283 various specimens are cited as "Lamoureux s.n. (UH)". I have never been on Pearl and Hermes Reef, and I have not been able to locate the cited specimens in the University of Hawaii herbarium. Specimens from P. & H. have been sent to me for identification, which may be the source of error. CHL.)

BEGA, R. V. 1974. *Phytophthora cinnamomi:* its distribution and possible role in ohia decline on the island of Hawaii. Pl. Dis. Reporter 58: 1069-1073.---*P. cinnamomi* was isolated from soil and rootlet samples throughout the "ohia decline zone" on the island of Hawaii. Fungus was isolated from roots of *Metrosideros collina* ssp. *polymorpha* ('ōhi'a-lehua), *Myrsine lessertiana* (kōlea), *Cheirodendron trigynum* ('ōlapa), and *Cibotium* spp. (hāpu'u).

BELIN-DEPOUX, M. and D. Clair-Maczulatjys. 1974. Introduction à l'étude des glandes foliaires de l'*Aleurites moluccana* Willd. (Euphorbiacée). I. La glande et son ontogénèse. Rev. gén. Bot. 81: 335-351.--On petioles of candlenut, at junction of petiole and leaf blade are a pair of glands. In lobed leaves these glands are closed and smooth, while in entire leaves each gland has a central pit. The structure and development of the glands is described. Sometimes 3 or 4 glands may be present, but each is smaller, and the total volume of glandular tissue equivalent to that in the typical pair of glands. At the base of the petiole, a pair of glands of similar structure is evident at an early stage of growth, but these glands, which are considered equivalent to glandular stipules, soon disappear.

BURGAN, R. E., F. M. Fujioka and G. H. Hirata. 1974. A fire danger rating system for Hawaii. Fire Tech. 10: 275-280.---Discusses problems in adapting U.S. Forest Service National Fire Danger Rating System to Hawaiian conditions. Reports on automatic data collection and computer processing system used to monitor fire problems in Hawaii.

CLAPP, R. B. and W. O. Wirtz II. 1975. The natural history of Lisianski Island, Northwestern Hawaiian Islands. Atoll. Res. Bull. 186: 1-196. --Compilation of previous studies plus considerable new information. Emphasis on birds, with sections on geology, climate, history, mammals, reptiles, and vegetation (several photos plus an annotated list of species with citation of specimens).

CRILEY, R. A., P. E. Parvin and F. D. Rauch. 1974. Timing container-grown poinsettias for Christmas market in Hawaii. Hawaii Agric. Exp. Sta. Dept. Paper 13. 16 p.---Presents data on 3 cultivars, Eckespoint C-1 Red, Annette Hegg, and Mikkel Rochford, grown at low elevations on Oahu, and at 3200 feet at Kula, Maui. Times of planting and types of pruning are discussed as they affect marketable dates for the plants.

DEGENER, O. and I. Degener. 1974. Appraisal of Hawaiian taxonomy. Phytologia 29: 240-246.---Review of St. John's (1973) "List and summary of the flowering plants in the Hawaiian Islands." The authors use this as a base to review changes in the Hawaiian flora brought about by activities of early Hawaiians, Spaniards (they present a photo of a rock statue in the *Museum für Völkerkunde* in Berlin which is interpreted as a Hawaiian representation of a Spanish grandee), and post-Cook immigrants and visitors. They further estimate that the Hawaiian flora at the time of Cook's visit consisted of 20,000 to 30,000 taxa, and that there may have been an endemic flora of 50,000 taxa before the advent of man.

----- and -----. 1975. Myrsine, Rapanea and Suttonia. Degeners' Flora Hawaiiensis Leaflet No. 2. 2 p.---Authors reiterate their opinion that *Rapanea* is the preferred generic name for Hawaiian koleas. They further point out that the Hawaiian tree which has previously borne a variety of names (*Myrsine lanceolata* Heller, 1897 - a later homonym of *M. lanceolata* Wallich, 1892 from India; *Suttonia angustifolia* Mez, 1902 and *Myrsine angustifolia* (Mez) Hosaka, 1940 - later homonyms of *M. angustifolia* D. Dietrich, 1839 from Reunion Island; *M. hosakae* Wilbur, 1965 - a later homonym of *M. hosakae* St. John, 1962 from Henderson Island) should now properly be called *Rapanea helleri* Deg. & Deg., 1971 (Phytologia 22: 213). For those botanists who wish to continue to use the generic name *Myrsine*, it will be necessary to publish a new combination elsewhere.

----- and -----. 1975. Concerning a magazine article. Degener's Leaflet No. 3. 6 p.---An open letter to "Smithsonian" magazine, commenting on the Jenkins and Ayensu article (cited below), criticizing a misidentification of an *Argyroxiphium*, and including several original photos of silverswords from various habitats.

* -----, ----- and N. Pekelo, Jr. 1975. Hawaiian plant names, their botanical and English equivalents. Fl. Haw. p. X_0 - X_{28}.---A compilation, from existing literature and original sources, of Hawaiian names for plants and their botanical equivalents, listed alphabetically by Hawaiian name. The list also offers an English common name for each entry, but in many cases either the English or Hawaiian name is newly coined by the authors.

DOTY, M. S. 1974. Coral reef roles played by free-living algae. Proc. 2nd Internat. Coral Reef Symp. 1: 27-33.---At Waikiki, Hawaii *Porolithon onkodes* is nearly the only species found intertidally or above the physiological low tide line, dominating the most brightly lit situations where shear of wave force reduces shade and grazing; *P. gardineri* is found below the same line. In shade of frondose algae and where shear from wave force is lessened, the genera *Sporolithon* and *Hydrolithon* predominate.

-----, W. J. Gilbert and I. A. Abbott. 1974. Hawaiian marine algae from seaward of the algal ridge. Phycologia 13: 345-357.---From dredge hauls between 10 m and 165 m depths in Hawaii 101 species of benthic algae have been found, 21 of which are recorded for the first time from Hawaii. No distinctive deep water flora, zonation, or dominance by one phylum was found. Substrate, biogeographic factors, motion, and fertilizer content of the water are postulated as significant in determining what species will be found at a given deep water site.

It is suggested that random variation in compensation points among species is responsible for the exponential decline in number of species as a function of depth.

FOSBERG, F. R., M. V. C. Falanruw and M.-H. Sachet. 1975. Vascular flora of the Northern Marianas Islands. Smithsonian Contr. Bot. 22: 1-45.---An annotated catalog of the vascular plants recorded from the northern 10 islands of the Marianas Archipelago in Micronesia. The islands treated are those from Farallon de Medinilla in the south to Uracas (Farallon de Pajaros) in the north. There is a brief geographical introduction, and for each plant species ecological and geographic data and specimen citations, or citations of literature records when no specimens are available.

----- and D. Herbst. 1975. Rare and endangered species of Hawaiian vascular plants. Allertonia 1: 1-72.---A compilation of information about the status of Hawaiian plants in the form of a list, in which various categories are recognized. The summary, which the authors emphasize is only preliminary, lists the following numbers of species (and varieties) in these categories: 273 extinct; 800 endangered; 99 rare; 34 local; 518 uncertain; 8 rare in Hawaii but native elsewhere as well; 33 in other categories (depleted, decreasing, increasing, stable, protected, cultivated).

----- and M.-H. Sachet. 1974. Plants of southwestern Polynesia. 3. Micronesica 10: 251-256.---Critical notes and records of species of *Ophioglossum* (Ophioglossaceae), *Waltheria* (Sterculiaceae), *Alyxia*, *Ochrosia* and *Neiosperma* (Apocynaceae) and *Morinda* (Rubiaceae).

FRIEND, D. J. C. 1975. Adaptation and adjustment of photosynthetic characteristics of gametophytes and sporophytes of Hawaiian tree-fern (*Cibotium glaucum)* grown at different irradiances. Photosynthetica 9: 157-164.---Based on changes in relationships between rate of photosynthesis at saturation by radiant energy and the irradiance during growth, gametophytes are shade adapted and show high shade adjustment. Sporophyte had low shade adjustment and adaptive features of both sun and shade plants. Morphological adaptations to increased shading include a narrowing of the prothallus, higher chlorophyll contents on fresh wt. basis of both sporophytes and gametophytes, reduced thickness of sporophyte fronds, and longer retention time of fronds of greater individual area.

GANGULEE, H. C. 1974. Mosses of Eastern India and adjacent regions. Fasc. 4: 408.---The earliest available name for Bartram's (1933. Manual of Hawaiian Mosses, pp. 109-111) *Webera mauiensis* Broth. and *W. gracilescens* Bartr. is *Pohlia flexuosa* Hook. The taxon is presently also known from the Himalayas, India, and Ceylon through Indonesia to Japan. Accompanied by excellent illustrations.

HAMILTON, R. A. and W. Yee. 1974. Macadamia: Hawaii's dessert nut. Univ. Hawaii, Coop. Ext. Serv. Circ. 485. 10 p.---Gives descriptive and botanical information on *Macadamia integrifolia* and *M. tetraphylla*, with notes on culture, propagation, climatic adaptation, soils and fertilization, diseases and pests, harvesting and processing.

HERBST, D. 1975. An introduction to the Hawaiian flora. Bull. Amer. Assoc. Bot. Gard. and Arb. 9: 49-52.---Semi-popular article on the origin of the Hawaiian flora, to serve as orientation for AABGA members attending the annual meeting on Kauai in September 1975. In the same number of the bulletin are brief descriptions of Pacific Tropical Botanical Garden, Olu Pua Gardens, Honolulu Botanic Gardens, Waimea Arboretum, and Harold L. Lyon Arboretum.

INOUE, H. 1974. *Temnoma setigerum* (Lindenb.) Schust. from the Hawaiian Islands. Bull. Natl. Sci. Mus. 17(3): 227-231.---The antipodal genus *Temnoma* (Pseudolepicoleaceae), with 9 species from the southern South America-New Zealand-Tasmania region, contains a single species (*T. setigerum*) reaching, in the Pacific, as far north as Fiji. *T. s.* var. *hawaiicum* Inoue var. nov. (type West Maui, leg. D. D. Baldwin 198 pp, YU) is described and illustrated.

ITOW, S. and D. Weber. 1974. Fens and bogs in the Galapagos Islands. Hikobia 7: 39-52.---Describes *Sphagnum* communities on San Cristobal, Santa Cruz, San Salvador, and Isabela islands, in highland areas. Fens, characterized by *S. cuspidatum* are found in shallow water-filled depressions. Raised bogs and vertical bogs are characterized by *S. erythrocalyx*.

JENKINS, D. W. and E. S. Ayensu. 1975. One-tenth of our plant species may not survive. Smithsonian 5(10): 92-96.---A survey of problems regarding endangered plant species in the U.S. The article points out that Hawaii's flora is among the most vulnerable and heavily damaged in the world, with about 50% listed as endangered or recently extinct.

KRAUSS, B. H. 1975. Ethnobotany of the Hawaiians. Univ. Hawaii: H. L. Lyon Arboretum Lecture No. 5: 1-32.---A survey of the plants used by the Hawaiians, and the uses to which they were put. Illustrated with line drawings of the major plant species and of various artifacts made from or used with these plants.

LAMOUREUX, C. H. 1975. Phenology and floral biology of *Monodora myristica* (Annonaceae) in Bogor, Indonesia. Ann. Bogor. 6: 1-25.---*Monodora myristica*, from Africa, flowers in Bogor at irregular intervals between February and October. Flowers are produced on new shoots which start growth a few days after old leaves have been shed. Each flower last about 25 days and continues growing throughout that time. Pollen grains germinate readily and potential pollinators visit flowers, but fruits do not develop even after hand pollination. Since all trees in Bogor belong to a single clone, failure to set fruit may be due to a self-incompatibility system.

LAUCHIS, R. W. 1975. A case for viewing tropical plants growing naturally. Bull. Amer. Assoc. Bot. Gard. and Arb. 9: 69-70.--Emphasizes the educational value of botanical gardens in the tropics, where tropical plants can be seen growing out of doors in fairly natural surroundings.

LITTLER, M. M. and M. S. DOTY. 1975. Ecological components structuring the seaward edges of tropical Pacific reefs: the distribution, communities and productivity of *Porolithon*. Journ. Ecol. 63: 117-

129.---*Porolithon gardineri* (6% cover) and *Lithophyllum kotschyanum* (7% cover) are the major species on the crest portion of Hawaiian algal ridges; *P. onkodes* (41% cover) is dominant on the heavily grazed seaward slope. *P. onkodes*, because of its role in maintaining and providing the surf-resistant reef edge, is one of the most important reef-building organisms. It is physiologically adapted to intense illumination and physically adapted to intense surf and grazing pressure. Estimates of productivity of the algal species are given.

MUELLER-DOMBOIS, D. 1975. Some aspects of island ecosystem analysis. as Chap. 23 (p. 353-366) *in* Golley, F. B. and E. Medina (eds.), *Tropical ecological systems -- trends in aquatic and terrestrial research*. New York: Springer Verlag.---Discusses isolation, size, and age as factors affecting island ecosystems. Then summarizes current work in Hawaii on spatial distribution of island biota (ecological amplitudes, hypotheses of species distribution), community structure and niche differentiation, successional phenomena (replacement of native by exotic species, recovery trends of native species after volcanic eruptions and after experimental herbivore displacement).

OCHI, H. 1974. Some Bryaceous "Old World" mosses, also distributed in the New World. Journ. Fac. Ed., Tottori Univ. (Nat. Sci.) 25: 35-41. ---Based upon study of type materials, *Bryum megalostegium* Sull. (type locality, Mauna Loa, Wilkes Expedition sn) and *B. mauiense* Broth. (type locality, West Maui, Baldwin 120 pp), both at one time considered to be endemic Hawaiian species, are newly placed into synonymy under the pan-tropical *B. nitens* Hook.

PETTYS, E. Q. P., R. E. Burgan and R. E. Nelson. 1975. Ohia forest decline: its spread and severity in Hawaii. U.S.D.A. Forest. Serv. Res. Paper PSW-105. 11 p.---Ohia forest decline - its severity and rate of spread - was studied by aerial photographic techniques on a 197,000-acre (80,000-ha) portion of the island of Hawaii. In 1954 only 300 acres showed signs of severe decline; by 1972 there were 85,200 acres of severely affected forest. Rate of decline and current severity were related to mean annual precipitation and to elevation. The epidemic is continuing. Some forests on other Hawaiian islands also display decline symptoms. (Authors' abstract)

SIEGEL, S. M. and C. Corn. 1974. Thermal and ionic factors in the ultraviolet photolysis of plant cell membranes. Physiol. Plant. 31: 267-270.--Exposures of red beet root tissue to ultraviolet causes release of betacyanin pigment after a 20 min induction period. UV-photolysis is temperature sensitive with a thermal threshold at about 10^{o}C. Reduction in pigment release was effected by chlorides of Mg, Ca, and Sr, but not by Li, Na, or K.

SMATHERS, G. A. and D. Mueller-Dombois. 1974. Invasion and recovery of vegetation after a volcanic eruption in Hawaii. U.S. Natl. Park Serv. Sci. Monogr. Ser. 5: xiv + 129 p.---Traces the development of vegetation in areas affected by the 1959 eruption of Kilauea Iki over the subsequent 9 years.

SMITH, A. C. and J. E. Haas. 1975. Studies of Pacific Island plants. XXIX. *Bleasdalea* and related genera of Proteaceae. Amer. Journ. Bot. 62: 133-147.---Monographic study of *Bleasdalea* (5 spp. of New Guinea, Queensland, New Hebrides and Fiji), and the related genera *Kermadecia* and *Sleumerodendron* of New Caledonia, and *Euplassa* and *Gevuina* of South America.

SMITH, C. W. and S. M. Siegel. 1975. Differential permeation of *Artemia* cysts and cucumber seeds by alcohols. Journ. Histochem. Cytochem. 23: 80-83.---Rate of penetration of simpler alcohols into dormant structures was studied. In solutions below 70% rate of penetration is related to lipid solvent capacity of the alcohol. In concentrations above 70%, particularly at 100%, methanol penetrates rapidly, ethanol slowly, propanol and butanol not at all. It is suggested that in dehydrated membranes the lipid moiety is protected by a continuous sheet of protein.

ST. JOHN, H. 1974. A new *Ervatamia* (Apocynaceae) from Makatea Island, Tuamotu Archipelago. Pacific Plant Studies 23. Pacific Sci. 28: 463-465.---*E. makateaensis*, described as new, is the second species of higher plant known to be endemic to Makatea.

-----. 1974. *Luteidiscus*, new genus (Compositae). Pacific Plant Studies 25. Bot. Jahrb. Syst. 94: 549-555.---The genus *Luteidiscus* (type species *L. calcisabulorum* St.J. sp. nov.) is established to include the type and those species formerly placed in the genus *Tetramolopium* which have yellow disk florets; species with purple disk florets are retained in *Tetramolopium*. Transferred from *Tetramolopium* are *L. capillaris* and *L. rockii* from Hawaii, and *L. alinae*, *L. ciliatus*, *L. cinereus*, *L. flaccidus*, *L. procumbens*, *L. prostratus*, *L. spathulatus*, and *L. virgatus* of New Guinea.

-----. 1974. *Skottsbergiliana* new genus (Cucurbitaceae) of Hawaii Island. Hawaiian Plant Studies 41. Pacific Sci. 28: 457-462.----*Skottsbergiliana* which has the seed enclosed in 3 outer envelopes, is segregated from *Sicyos*, with the seed enclosed in a single envelope. The holotype of the new genus is *Sko. lasiocephala* (Skottsb.) St. John, from North Kona, and the new species *Sko. partita* is described from the same area.

-----. 1975. More variants of *Scaevola taccada* (Goodeniaceae). Hawaiian Plant Studies 43. Proc. Biol. Soc. Wash. 88(8): 73-76.---*S. taccada* var. *bryanii* is described as a new variety from Midway, and the new combination *S. taccada* var. *fauriei* is made for upland plants from the Haupu Mountains and the Napali Coast of Kauai.

-----. 1975. Plantae Hobdyanae Kauaienses II. Hawaiian Plant Studies 45. Bot. Mag. Tokyo 88: 59-64.---Three new taxa are described from Kauai, Hawaii, based on collections by Robert W. Hobdy: *Psychotria rosacea* (Rubiaceae), *Cyanea asarifolia* (Lobeliaceae), *Bidens mauiensis* var. *ciliata* (Compositae).

-----. 1975. *Cenchrus laysanensis* (Gramineae) of the Leeward Islands. Phytologia 31: 22-24.---*Cenchrus agrimonioides* var. *laysanensis* F. Br. of the Leeward Hawaiian Islands is raised to specific rank.

-----. 1975. Revision of the genus *Pandanus* Stickman. Part 38. *Pandanus* in Fiji, first group (except Section *Pandanus*). Pacific Sci. 29: 55-77.---Eight species from 4 sections are treated. Newly described taxa are: Sections *Digitati* and *Radiatistigma*, species *P. varawa*, *P. taveuniensis*, *P. gillespiei*.

----- and D. Herbst. 1975. An earlier name for *Bobea elatior* (Rubiaceae). Hawaiian Plant Studies 46. Phytologia 30: 7-8.---The correct name for this 'ahakea is *Bobea Gaudichaudii* (C. & S.) St. John & Herbst.

STONE, B. C. 1974. The correct botanical name for the breadfruit. Journ. Polynesian Soc. 83: 92-93.---Concludes that the correct botanical name for breadfruit is *Artocarpus altilis* (Parkinson ex "Z") Fosberg.

-----. 1974. Towards an improved infrageneric classification in *Pandanus* (Pandanaceae). Bot. Jahrb. Syst. 94: 459-540.---A synopsis treating 8 subgenera, 61 sections, and 468 species. Keys to subgenera, sections, and subsections are included. In an appendix 2 new species are described: *P. cheilostigma* from the Philippines and *P. linguiformis* from Madagascar.

WALTERS, G. A. 1974. Polystyrene bullets not satisfactory for reforestation in Hawaii. Tree Pl. Notes 25(2): 22-23.---Seedlings of *Eucalyptus saligna* and *Acacia koa* were grown in 4½ in. long polystyrene "bullets" for planting with a hand-operated mechanical action "gun." After 14 weeks roots were often growing into adjacent bullets making separation difficult. In clay soils in Hawaii only 10 seedlings were successfully planted out of 50 attempts, and these 10 seedlings eventually died. In rocky soil none of 20 seedlings tried was successfully planted.

-----. 1974. Styroblocks: new technique for raising and planting seedlings in Hawaii. Tree Pl. Notes 25(4): 16-18.---Polystyrene is formed into lightweight rigid holders called BC/CFS styroblocks containing tapered cavities. Cavities are filled with planting medium and seeds are planted in each. When seedlings reach transplanting size, they are extracted and the conical root-soil mass remains intact for planting in a hole formed in the proper shape by a special dibble. Trials with 4 spp. on 4 soil types were successful, with seedlings showing over 95% survival and high vigor after 3 months.

-----. 1974. Seedling containers for reforestation in Hawaii. pp. 336-338 *in* Proc. North Amer. containerized forest tree seedling symposium, Denver, Colorado, Aug. 26-29, 1974. Great Plains Agric. Council Pub. No. 68.---For reforestation in Hawaii 3 techniques of growing seedlings in a container and then field-planting them have been tried. The Walters' Bullet was unsatisfactory. The BC/CFS Stryoblock was satisfactory in a test of 4 hardwood spp. planted on 4 different soils. The Hawaii Dibbling Tube shows the most promise.

WHITESELL, C. D. 1974. Planting trials of 10 Mexican pine species in Hawaii. U.S.D.A. Forest. Serv. Res. Pap. PSW-103. 8 p.---Ten spp. of Mexican pines were planted on adverse sites at 6450 ft. elevation on Maui, and 5 spp. on similar sites at 3200 ft. on Molokai. Initial survival was poor because of low quality of planting stock and harsh site conditions, but subsequent mortality was low. Growth and vigor have been satisfactory. Average annual height growth 5 yr. after outplanting ranged from 1 to 3 ft. on Maui and 1 to 2 ft. on Molokai. Results suggest that Mexican pines would be suitable for reforestation on adverse sites at higher elevations in Hawaii. (Author's abstract)

YEN, D. E. 1974. The sweet potato and Oceania. An essay in ethnobotany. Honolulu: Bernice P. Bishop Mus. Bull. 236. xvi + 389 p.---An impressive marshalling of observations and data, botanical, horticultural, ethnological, and archeological, in an effort to treat the sweet potato "problem" of the Pacific. The summary is quoted here: "Plant Introduction: The Tripartite Hypothesis. The sweet potato was transferred from South America to Polynesia between A.D. 400 and 700, possibly by Polynesian voyagers. The 16th-century voyagers of Portugal and Spain were to transfer the plant from America to Indonesia and the Philippines, respectively. The Portuguese introduction was indirect, from the West Indies through Africa and India; the Spanish route was more direct from western Mexico and Peru on what was to be the Manila Galleon route through Micronesia." "Adaptation: Sweet Potato Dominance In The Marginal Tropics. In Pacific agricultural systems, the sweet potato dominates, or did dominate other tropical food-plant species in marginal areas. Marginal here refers to edaphic and climatic conditions in which the adaptibility inherent in the sweet potato was exploited on its introduction into subsistence systems. The variability of its role in agricultural systems and its cultivation technology may be said to be consistent with its own genetic variation."

NEW PERIODICALS

Allertonia. A series of occasional papers, published irregularly. It is intended as an outlet for publication of longer papers presenting results of original research undertaken by staff members of the Pacific Tropical Botanical Garden, or in collaboration with the Garden and its programs. The title commemorates Robert Allerton (1873-1964), one of the first trustees of the Garden, whose generosity was instrumental in its establishment. Information may be obtained from, and standing orders placed with, the Publications Secretary, Pacific Tropical Botanical Garden, P.O. Box 340, Lawai, Kauai, Hawaii 96765.

Bryophyta Hawaiica Exsiccata, being decades of Hawaiian mosses. Edited and distributed by W. J. Hoe. This *Exsiccata* is being issued in decades at irregular intervals to make available to the botanical community a recent and ultimately comprehensive representation of Hawaii bryoflora. Series I deals with mosses, Series II with hepatics. Each decade consists of a set of 10 herbarium specimens together with a pamphlet containing notes on identification, collection data, distributional and taxonomic information. A total of 52 duplicate sets is being prepared and distributed to various herbaria.

Institutions and individuals interested in receiving this *Exsiccata* may request an application form from W. J. Hoe, Department of Botany, University of Hawaii. To date the following decades of Series I have been issued: 1, June 1974; 2, March 1975; 3, April 1975.

Pacific Islands Studies and Notes. This publication, which appears at irregular intervals, is published privately by N. L. H. Krauss, 2437 Parker Place, Honolulu, Hawaii 96822. It deals with various aspects of the Pacific islands - geography, history, bibliography, etc., and is being sent to selected libraries. No manuscripts from other persons will be accepted for publication at present. When sufficient numbers to form a volume have been published a title page and index will be issued. This series started in 1971. To date 17 numbers have been issued, all by N. L. H. Krauss, each dealing with the bibliography of an island or island group, emphasizing the less-well-known islands. No. 16, Bibliography of the Lihir Islands, New Guinea, and No. 17, Bibliography of the Tabar Islands, New Guinea are the latest issues. Each includes brief geographic and historic notes and a bibliography, arranged alphabetically but cross-listed by topics (e.g., Anthropology, Birds, Census, Geography, Medicine, etc.).

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* Assigned for review.

REVIEW:

SAMOAN VERSUS HAWAIIAN MOSSES (MUSCI)

Meeting in Leningrad during the XII International Botanical Congress, Dr. Wolfram Schultze-Motel of Berlin-Dahlem informed us that he would mail us a copy of his monograph concerning *Die Moose der Samoa-Inseln,* appearing in Willdenowia (7: 333-408. 1974.) On our return to Hawaii we were delighted to find the copy, with six colored photographs and three diagrams, awaiting us.

The author visited Manono, Savai'i, Tutuila and Upolu from April to June 1972, collecting 1,498 numbers. These, mostly mosses (*Musci*), are properly cited in the text. On his return to Berlin-Dahlem, he sojourned from June 22 to 30 in Honolulu. Among the eleven sections of the monograph, he deals with Topography; Geology; Climate; Flora of Ferns, Flowering Plants and Mosses; Moss Associations; Human Population Explosion at the Expense of the Native Biota; and (Lack of) Conservation. In fact, on pages 348-349 he deplores the destruction of the endemic biota of Samoa by man in his continuous search for more arable land. He quotes appropriately Van Steenis that "...no agronomist has been able to prove that an unborn baby to be added to the three billion of existing people is worth more for our civilization than the life of a now existing orang-utan or rhinoceros, magnificient creations of evolution." Though members of most destructive of Primates ourselves, we reviewers can visualize what a Paradise for myriads of humbler taxa of plants and animals this World would be were our species reduced through birth control or otherwise by 99%.

Pages 349 to 403 are devoted to pure systematics. Comparing the Hawaiian Archipelago with that of the Samoan, using for convenience Degeners & Hoermann's publication (Mosses of Hawaii. Degeners' Flora Hawaiiana Leaflet No. 2: 1-8. 1973.), we find that both are just about short of forty families, of which about 23 are common to both archipelagos. Of the 202 species presently known from the Samoan, about 43 genera are represented by a single species; the rest having 2, 3, 4, 5 and 6 until we come to *Bryum* with 7, *Fissidens* with 10, *Calymperes* with 14, & *Ectropothecium* with a large swarm of yet uncounted taxa. For the Hawaiian Archipelago, we expect the further discovery of a few additional species with continued exploration of such fascinating areas as the outer slopes of Haleakala, and of Eke and Puu Kukui; for the Samoan, very, very many more.

As in the case of the moss flora of the Hawaiian Archipelago, a few species in the Samoan can be considered pantropic; otherwise relationship with the New World is practically wanting. This is astonishing when one notes that lichens of the Hawaiian, as shown by Oscar Klement (1966. Zur Kenntnis der Flechtenflora und -Vegetation des Hawaii-archipels. Nova Hedwigia 11: 243-283.) are closely related to lichens of South America!

Species found growing in the crowns of trees, even in the fog- and rain-belt, are occasionally exposed to extreme dry spells and to unusual intensity of ultraviolet light. This last factor is somewhat mitigated by such mosses possessing a thicker cell wall and being brilliant red through claret to almost black. Parts of the same individual plant when shaded, Schultze-Motel reminds us, are green. This interesting adaptation, so common all about us and so easily observed when walking along the Fossil Footprint Trail in Hawaii Volcanoes National Park, hardly gets the attention it deserves.

Crevices of Savai'i's more recent *a'a* and *pahoehoe* flows, designated as *mu* in the vernacular, harbor such genera as *Brachymenium*, *Campylopus*, *Macromitrium*, *Mniomalia* and *Philonotis*.

A few questions regarding orthography occur, such as on page 351. There we should like to read "*Fissidens daltoniifolius*; and on page 375, "*Hypnodendron*." We have been using "*Rhacopilaceae*," while Schultze-Motel on page 379 and elsewhere uses "*Racopilaceae*" and "*Racopilum*."

The specialist on Phanerogams should not be confused by the estimate made in 1910 by the elder Rechinger, unfortunately quoted by Schultze-Motel, that only 688 species of "*Siphonogamen*" occur in Samoa. A casual stopover in Samoa by one of the reviewers convinced him that this statement is just as absurd for Samoa as is the one that the "Native specific and Infraspecific plants" number a mere 2,668 for the Hawaiian Islands.

The bibliography comprises 130 references. Though Bartram's excellent manual of Hawaiian mosses is cited, there is no reference to the more recent publications of W. J. Hoe nor of Degeners & Hoermann. A copy of the last was mailed to Berlin-Dahlem March 31, 1973; while Dr. Schultze-Motel's monograph was completed November 24, 1973. For any one studying mosses throughout the Pacific and its western borders, *Die Moose der Samoa-Inseln* is indispensable.

Otto and Isa Degener
P.O. Box 154
Volcano, Hawaii

NOTES FROM THE LYON ARBORETUM - II

PEOPLE IN TOWN - Dr. Albert C. Smith, Torrey Professor of Botany at the University of Massachusetts and two of his graduate students were in Honolulu this past summer. Those of us who remember the old "Dean Hall days" also remember the biogeography and plant evolution course which Dr. Smith taught for many years as Wilder Professor of Botany. He is a Research Affiliate of the Lyon Arboretum and delivered the first annual Harold L. Lyon Arboretum Lecture in 1970, entitled "The Pacific as a key to flowering plant history." Before his return to Massachusetts Dr. Smith delivered an informal coffee-hour seminar at the Arboretum on July 10th, in which he discussed the developments in biogeography during the past five years.

Kenneth Nagata
Harold L. Lyon Arboretum

LYON ARBORETUM ASSOCIATION

With its transfer from the HSPA to the University in 1962, the functions of the Arboretum were expanded to include research and instructional support of the University community and ultimately, of the public. At that point and for several more years, however, the Arboretum was largely unknown to the public. To reach the public and to meet its needs, service and educational programs were established in the ensuing years. This increased activity led to the formal organization of a public support group in July 1974, the Lyon Arboretum Association.

The organization is open to all persons interested in assisting the Arboretum "in attaining its objectives by sponsoring and assisting in educational, research and development programs, providing aides and guides, and executing special projects" (Constitution and By-laws). Volunteers are currently assisting the staff in a gamut of activities ranging from "indoor" work in the herbarium, library, office and greenhouse, to grounds activities in the taro patch, lawn areas and planted sections. Volunteer guides have also permitted the Arboretum to accomodate a greater number of tours of both public and school groups.

The Association is currently sponsoring courses and workshops open to the general public. Included are Orchid Culture, Ethnobotany of the Hawaiians, Lau Hala Plaiting, Tongan Basketry, Hawaiian Plant Leis, Container Gardening, Home Vegetable Gardening and more. The 6-week classes are held at the Arboretum during fall, winter and spring sessions. Due to the demand, a special series of summer workshops was also presented. Other Association activities include the publication of a quarterly newsletter and recently, a special open house of the Arboretum for the membership and friends.

The organization has grown to over 500 memberships in just over a year. It has also been granted a non-profit status.

Information: Lyon Arboretum Association, 3860 Manoa Road, Honolulu, Hawaii 96822. Phone: 988-7378 between 9:00 am and 12:00 pm on weekdays.

Sharon Ishikawa
Harold L. Lyon Arboretum

Ed. note. The following testimony was given by Society Vice-President Sheila Conant at a public meeting held by the Oahu Fish and Wildlife Advisory Committee. The purpose of this meeting was to receive public input on the policies and activities of the State Division of Fish and Game concerning conservation, fishing and hunting.

September 23, 1975

The Hawaiian Botanical Society feels that there is ample evidence to demonstrate that feral ungulates are extremely detrimental to the continued existence of native Hawaiian plants and their associated ecosystems. In view of this, we recommend that the Division of Fish and Game make a concerted effort to open new areas of the state to hunting. While opening new areas for hunting is perhaps easiest to do in areas that are owned by the state, we also encourage any efforts that could be made to open hunting on private lands. We would particularly like to recommend that the Kulani Project area on the Big Island be opened to pig hunting because pig populations are very high and their potential for damage to the area is great. The particular forest type that is found in this area has a very limited distribution and is worthy of protection from pigs.

It also contains at least two rare and endangered native plants.

We recommend that open seasons on game animals should be effective in areas that have been or will be designated as critical habitat for endangered plants and animals and their associated ecosystems. The goal of hunting in such areas should be extermination of game animals. We urge that sheep hunting in the mamane-naio (*Sophora chrysophylla-Myoporum sandwichense*) forest on Mauna Kea to be carried to the extermination point because this area is critical habitat for the Palila (*Psittirostra bailleui*), and the sheep are seriously damaging the habitat.

In other areas (i.e., those not designated as critical habitat) we suggest that game animal populations be kept as low as possible so that there is a minimum of damage to native vegetation.

The Hawaiian Botanical Society urges that the Division of Fish and Game take action to see that no new game animals are introduced to the state because of their potential for damage to native vegetation. We also urge that the Division, in conjunction with appropriate state agencies, discourage the introduction of new species of plants into Hawaii or any of its islands because such plants may displace native plant species. We also urge the adoption of a policy to actively eliminate aggressive exotic plants such as *Clidemia hirta* on Oahu and *Lantana camara* throughout the state. Such a policy should be helpful in allowing regeneration and in preventing furhter decline of native vegetation, thus providing suitable habitat for native Hawaiian plants and animals.

DR. HAROLD ST. JOHN

Dr. Harold St. John has recently received two major awards. In Washington, D. C. in April, he was awarded the Medal of Honor of the Garden Club of America for outstanding and distinguished service to horticulture. The Medal of Honor, which is the highest award made by the Garden Club of America, was previously presented to such distinguished plant scientists as Charles Sprague Sargent, Liberty Hyde Bailey, David Fairchild and Richard A. Howard. The citation accompanying the award reads:

> Dr. St. John, Professor of Botany Emeritus at the University of Hawaii and a student of Hawaiian flora for more than 45 years, is recognized internationally as one of the few scientists who have become authorities on the unique flora of these islands. Dr. St. John, after whom *Hibiscus Saintjohnianus*, a native plant with rich orange-red flowers, was named, is the author of many botanical publications, including *List and Summary of the Flowering Plants* in the Hawaiian Islands. In addition to his

> position at the University of Hawaii, he has lectured in universities in Europe, Asia, Africa, and the Pacific.
>
> The Garden Club of America is pleased to award the Medal of Honor to Dr. Harold St. John, botanist, teacher and author of definitive studies of cultivated and natural flora, whose service to horticulture is respected from New England to the Pacific Atolls.

In September St. John was further honored by receiving the Award of Merit of the American Association of Botanical Gardens and Arboreta at its meeting on Kauai. The citation accompanying this award reads:

> The American Association of Botanical Gardens and Arboreta presents an Award of Merit to Dr. Harold St. John for his distinguished services to botany and horticulture.
>
> Dr. St. John has had a formal teaching career which spanned forty-six years in academic locales, but he hasn't stopped yet. After graduating from Harvard University with bachelor's and doctor's degrees, he served the Department of Botany at State College in Washington for a decade. In 1929 he came to Hawaii, where for thirty years he was professor of botany, chairman of the department at the University of Hawaii, botanist at the Bishop Museum, associate director of the Manoa Arboretum, and source of knowledge of Hawaiian and Polynesian plants. His teaching and research have inspired innumerable students, spanning as they do not only the eastern and western fringes of the mainland, but those of the fiftieth state as well, from the Big Island of Hawaii to the shorelines of Niihau.
>
> Following his formal retirement to emeritus status in 1958, Dr. St. John had appointments as a visiting professor in the United States and abroad, but he devoted most of his energy to his research and publications. His work on the large and diverse genus *Pandanus* has involved field work in many tropical areas and study of specimens in herbaria of the world. No project or Dr. St. John's is ever completed and forgotten, for this past summer he returned to Mt. St. Helens in Washington to update a vegetational study made fifty years ago. In 1973 the Pacific Tropical Botanical Garden published, as its Memoir Number I, Dr. St. John's manuscript entitled "List and summary of the flowering plants in the Hawaiian Islands." This is the first bibliographic compilation of all the native, introduced and cultivated plants of Hawaii.
>
> We honor Dr. Harold St. John for these and for his many other contributions to botany.

C. H. Lamoureux
Department of Botany
University of Hawaii - Manoa

ON COLLECTING MUSHROOMS FOR IDENTIFICATION

It is at this time of year that mushrooms are deposited on my desk with a plea for a name. Most of them are very much the worse for wear and are generally a slimy and frequently fetid mess. In order to give the air conditioning unit a chance to recuperate and also to improve the possibility of your receiving a name, I offer the following guidelines to collectors:

Collect the mature mushroom and if possible one or two immature specimens. Let the mushrooms dry out in the sun, or over moderate heat. Do *not* try to keep them in a fresh condition. It is a waste of time and failure is inevitable. However, it is important that certain information be obtained while the specimen is fresh. Make a spore print within 2-3 hours of collection. Take a piece of white paper and place the mushroom, gills down, on the paper after removing the stalk. Cover it with a glass jar. If you have only one specimen poke a hole in the paper large enough for the stalk to pass through and then let the gills rest on the paper. After an hour or so, remove the mushroom and leave the paper to dry for a short period. Fold the paper in two with the spore print on the inside and keep with the mushroom. Save the spore print even if you cannot see it, as many mushrooms have a white spore print.

Record the following data:

A. CAP
   Diameter
   Color
   Is it sticky, does it look waterlogged or is it dry?
   Does it have scales, lines or other markings?

B. GILLS
   Color

C. STALK
   Always dig the mushroom out of the ground and then clean off any soil and debris. Do *not* pull it out.
   Length and width
   Color
   Is it tough or fragile?

D. HABITAT
   Is it in soil, on a log, in humus?
   What is growing closeby?

If you are collecting specimens in the field and will not be able to process them for several hours, wrap them in waxed paper. Do not use plastic bags, as the specimens tend to stick to the plastic, destroying important characteristics.

C. W. Smith
Department of Botany
University of Hawaii - Manoa

REPORT ON THE THIRTEENTH PACIFIC SCIENCE CONGRESS

The 13th Pacific Science Congress was held at the University of British Columbia, Vancouver, Canada from August 18 to 30, 1975. Several members of the Hawaiian Botanical Society were in attendance. Among the symposia of special interest were those on: Floristic Needs in the Pacific Basin; The origins of Pacific land biota; Pacific ecosystems: a geographical analysis; Ecological reserves; Conservation and environmental protection.

During the symposium on ecological reserves it was announced that the government of British Columbia have named the largest such reserve, 24,300 acres on the west coast of Graham Island in the Queen Charlotte Islands, as The Vladimir J. Krajina Reserve. Dr. Krajina, a member of HBS, was honored for his work in establishing the ecological reserves system in British Columbia, which is widely regarded as among the most successful and comprehensive system anywhere in the world.

Dr. M. S. Doty has resigned from his position as Chairman of the Scientific Committee on Botany of the Pacific Science Association, after many years of effective work. The new Chairman named by the Pacific Science Council is Dr. H. A. Miller, Department of Biology, Florida Technological University, Orlando, Florida 32816.

The 3rd Inter-Congress of the Pacific Science Association will be held in Indonesia in 1977, and the 14th Pacific Science Congress will be held in Novosibirsk, U.S.S.R., in 1979.

At the closing ceremonies, the 13th Pacific Science Congress adopted several resolutions. Among those of interest to HBS are:

RESOLUTIONS OF THE PACIFIC SCIENCE ASSOCIATION

I. WHEREAS the International Convention on Trade in Endangered Species of Flora and Fauna was concluded in Washington in 1973 and, following ratification by the requisite number of nations, it came into effect on July 1, 1975;

AND WHEREAS implementation of the convention is an urgent matter, bearing in mind the existing threats to the species involved;

AND WHEREAS most nations of the Pacific basin have not yet ratified this important convention;

THEREFORE, be it resolved that all Pacific governments be urged, as a matter of priority, to ratify the Convention without delay.

II. WHEREAS the urgency for conservation in the face of the extinction of species was emphasized by Ian McTaggart Cowan in his Presidential Address; WHEREAS it has been a continuing emphasis of presentations during the Congress, indicating the concern of delegates;

WHEREAS the Convention on International Trade in Endangered Species of Wild Fauna and Flora was developed at a conference of some 80 nations held in Washington, D.C., U.S.A., in February-March, 1973; WHEREAS the Convention came into effect July 1, 1975; and WHEREAS the Convention regulates the international exchange of rare plants and animals considered vulnerable to extinction;

THEREFORE be it resolved that the Pacific Science Association and members of the 13th Pacific Science Congress in recognition of man's responsibility to conserve other life forms recommends that each government of a member country or area consider ratification and vigorous implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

III. WHEREAS man's natural and cultural heritage is rapidly changing or disappearing due to the acceleration of modern development, thus contributing to an impoverished progeny; WHEREAS environmental impact studies and ecological surveys are increasingly straining the human and physical resources of existing museums; and WHEREAS basic taxonomic revisions and identification keys are lacking for many plants and animals and because such keys are necessary to management, use, and enjoyment of the environment;

THEREFORE be it resolved that governments be urged to help save this heritage by establishing new museums and by supporting established ones through: (1) provision of qualified staff to meet increasing demands; (2) adequate building space to house growing collections, including libraries, and (3) funds for the continuing care and study of these collections so that new knowledge many be disseminated by publications and exhibits.

VI. WHEREAS there is good evidence of the recent spread of the important vector mosquito of dengue and yellow fever, *Aedes aegypti*, both in the Pacific and the Americas;

THEREFORE, be it resolved that all public health agencies in the region be encouraged by the Association to take urgent action to control and prevent the spread of this highly dangerous vector species.

VII. WHEREAS some species of animals imported into countries of the Pacific region have proven to be harmful to agriculture, natural resources, and public health; WHEREAS in the past controls on importations were exerted only after serious and expensive damage and hardship had occurred, and WHEREAS attempts to import species of wildlife often result in severe depletions of numbers in other countries and/or extensive losses of creatures in transit;

THEREFORE, be it resolved that the Pacific Science Association endorses the principle that governments should restrict importations of non-native wildlife. Be it further RESOLVED that the Association urge governments to encourage pet dealers to develop sales programs centered around those species which can be propagated under controlled artificial conditions in lieu of importations from other countries.

IX. WHEREAS the Pacific region possesses distinctive flora and fauna including numerous endangered species and a broad range of ecosystems; WHEREAS animal and plant life forms, both terrestrial and aquatic, are biological riches that are vulnerable to the growth of population and technology, especially on isolated islands; WHEREAS these unique natural resources must be preserved, both to provide baselines against which environmental changes can be measured, and for the enrichment of future generations of mankind; WHEREAS systems of ecological reserves can support natural communities large enough to remain as unmodified samples of each country's special living heritage; and WHEREAS special programs on Pacific ecosystems and ecological reserves have shown that, while a few governments, such as that of the Canadian Province of British Columbia, have a well-advanced network of reserves, many countries are in the earliest stages or have not yet begun;

THEREFORE, be it resolved that all countries be urged to place the highest priority on planning, designing, and effectively protecting a system of ecological and/or biosphere reserves as defined by UNESCO's MAB program.

X. WHEREAS it has been established in the 13th Congress Symposium "Floristic Needs in the Pacific Basin" that knowledge of existing floras is seriously deficient in many Pacific areas and that manuals usable by residents, ecologists, conservationists, other scientists and governmental agencies are an urgent need for both the immediate and long-range future of mankind in the Pacific;

THEREFORE be it resolved that the production of floras and floristic manuals become a matter of active concern by each country as expressed by provision of financial and institutional support for scientists involved in development of such floristic works.

Editor's Note: A number of Society members attended the Vancouver meeting and many papers of direct interest to our readers were scheduled. A listing of some of these follows:

AQUATIC RESOURCES AND THEIR MANAGEMENT

Doty, M. S., G. A. Santos and V. B. Alvarez: Current status and future prospects for *Eucheuma* culture.
Soegiarto, A. The state of pollution in coastal water environment of Indonesia.

BOTANY

Abbott, I. A. Floristic needs in the Pacific basin: Algae.
Becker, R. E. The phytosociological position of tree ferns in the Hawaiian rain forests.
Bridges, K. W. and W. Liggett. Development of an information system for Pacific natural areas.

Cooray, R. G. Stand structure and map of a montane rain forest on Mauna Loa, Hawaii.

Fosberg, F. R. Biogeoclimatic patterns in Micronesia.

----- and M. Sachet. Micronesia: Status of floristic knowledge.

Gay, R. Floristic and environmental variations throughout the *Metrosideros* forest belt on Hawaii.

Gressitt, J. L. Biogeographic relationships of New Guinea and New Caledonia.

Kartawinata, K. Structure and composition of forests in some nature reserves in West Java, Indonesia.

-----. The ecological zones of Indonesia.

Krajina, V. J. Revision of biogeoclimatic zonations in British Columbia.

Lamoureux, C. H. Phenological patterns in relation to ecological zones on Hawaii.

Miller, H. A. and H. O. Whittier. Floristic needs in the Pacific Basin - Mosses and Liverworts.

Mueller-Dombois, D. The Mauna Loa transect study of the Hawaii IBP.

----- and W. C. Gagne. Hawaiian Islands: Identification of principal natural terrestrial ecosystems.

Rifai, M. A. Floristic needs in the Pacific Basin: Fungi, infraspecific delimitation and geographic distributions.

Sachet, M. and F. R. Fosberg. The Marquesas in Pacific plant geography.

St. John, H. Floristic needs in the Pacific Basin - Polynesia.

CONSERVATION AND ENVIRONMENTAL PROTECTION

Baker, J. K. The conservation of rare and endangered species and ecosystems in the Hawaiian national parks.

Balazs, G. H. The green turtle (*Chelonia* sp.) in the Hawaiian Archipelago - A case study of an endangered Pacific resource.

Force, R. W. The role of museums in the conservation of nature and heritage: Access to and the use and control of collections.

Gagne, B. H. Present and future status of the terrestrial mollusca of Hawaii.

Gagne, W. C. Present detrimental perturbations on Hawaiian rare and endangered biota and their ecosystems.

Howarth, F. G. Hawaii's cave ecosystem, its distribution, environment energy and unique fauna.

SCIENTIFIC STUDY OF CORAL REEFS

Grigg, R. The impact of raw sewage effluent on shallow reef corals off Honolulu, Hawaii.

ECOLOGICAL RESERVES

Fosberg, F. R. An overview of natural area preservation in the world.

Krajina, V. J. Progress of ecological reserves in British Columbia.
Montgomery, S. L. The Hawaii State natural area reserves system.

ENERGY AND THE PACIFIC REGION

Grabbe, E. M. Geothermal and other natural energy sources in Hawaii.

LAND-BASED RESOURCES AND THEIR MANAGEMENT

Chou, C. H. and C. C. Young. Phytotoxic substances in twelve subtropical grasses.
Conant, S. Accomplishments of the US/IBP ecosystems integrated research program.
Haudricourt, A. Toward a gene bank of food plants of the islands of the Pacific Ocean.
Manko, Y. I. Recent volcanic activity: A factor in vegetation dynamics.
Sastrapradja, D. S. Some notes on the problems of conservation and exchange of plant genetic resources in the Pacific.
Sastrapradja, S. The need to intensify the use of plant genetic resources in the Pacific.
Soegiarto, A. The need of developing a marine-park system in Indonesia.
Thaman, R. E. Detrimental and favorable effects of exotic weed species on Pacific Island ecosystems and cultural complexes.

MAN'S FUTURE CONDITION

Force, R. W. Tourism and change: Stimulus and reaction.

MAN'S PLACE IN THE ISLAND ECOSYSTEM REVISITED

Fosberg, F. R. Development of ecosystem concept 1961-1975.

NUTRITION

Vidal, J. E. Wild edible plants in Laos.

THE ORIGINS OF PACIFIC LAND BIOTA

Clemens, W. A. Plate tectonics and the origin of the Pacific land biota.
Diamond, J. M. Dynamics of island biogeography in the Pacific.
Gressitt, J. L. Dispersal and the origins of the Pacific land biota.
Montgomery, S. L. Isolation and evolution on an island: Predatory Geometrid caterpillars on Hawaii.

C. H. Lamoureux
Department of Botany
University of Hawaii - Manoa

CALENDAR OF UPCOMING EVENTS

October

20 Hawaii Audubon Society Meeting. Waikiki Aquarium. 7:30 pm. Dr. Arthur Reed (University of Hawaii - Manoa) will give an illustrated talk entitled "Corals, coral reefs and what lives there."

November

3 Bot. Soc. Meeting. St. John 011. 7:30 pm. Dr. William Theobald (PTBG) giving an illustrated talk entitled "PTBG - Past, present and future." Plant donation and raffle night!

17 Hawaii Audubon Society Meeting. Waikiki Aquarium. 7:30 pm. 16 mm film and panel discussion on the Leeward Hawaiian Islands as bird sanctuaries.

December

15 Hawaii Audubon Society Meeting. Waikiki Aquarium. 7:30 pm. Walter Donaho will give an illustrated talk on his recent trip to Australia, New Zealand and India.

NAMES AND NOTES

Peter A. Bowler, formerly Research Associate in the Department of Plant Pathology, will be on a post-doctoral NRC fellowship at the National Museums of Canada (Ottawa) during 1975-1976. He will be working with Irwin Brodo, an eminent North American lichenologist....*David K. Smith,* bryologist at the University of Tennessee, and his wife *Mary*, recently visited Hawaii on their return to Knoxville from a collecting trip to Adak in the Aleutian Islands. Besides his continuing interest in the bryoflora of the Aleutians, Dave is presently involved in an examination of certain genera of Mexican mosses...*Jeff Granoff* (Department of Systematics and Evolutionary Biology, University of Connecticut, Storrs) visited Hawaii briefly after attending the A.I.B.S. meeting in Oregon. He is working on leaf variation within the genus *Selaginella* and would like both living and FAA-fixed material of *S. deflexa*...Long-time Society member *Alvin K. Chock,* his wife *Yona,* and their three daughters *Makana, 'Alana,* and *Malama,* left in July for Rome, Italy where Al will be the Agricultural Officer (Plant Quarantine) in the Plant Protection Service of the U.N.'s Food and Agricultural Organization. Previous to this, he was with the Operations Division, Office of Pesticide Programs, USDA, involved in reviews of state plans for the certification of Pesticide Programs....*Dr. Carl Troll* of the Geographical Institute (University of Bonn, Germany) died July 21, 1975. He was much interested in the flora of the Hawaiian Islands and since July 1959 received reprints from the

Degeners....A post-doctoral Smithsonian Research Fellowship to work with *Psychotria* has taken *Sy H. Sohmer* to Washington, D. C. He is being accompanied by his wife *Sara,* and daughters *Rebecca Rose* and *Rachel Adrienne.* Presently on leave as an Associate Professor in the Department of Biology at the University of Wisconsin-La Crosse, he participated in the flora of Ceylon Project from September 1973 to January 1974.....Newly appointed as Director of the Marion Ownbey Herbarium and Assistant Professor of Botany, *Amy J. Gilmartin* is presently at Washington State University at Pullman. She is principally interested in systematics research and teaching in numerical phenetics, theoretical taxonomy and the floristics of the New World's tropical and temperate regions. She is currently engaged in developing practical numerical criteria of intragroup variability and applying these to measure altitudinal and latitudinal effects upon overall variation within populations. Her dissertation "The Bromeliaceae of Equador," done at the University of Hawaii, was published in 1972 by J. Cramer as volume 5 of the series *Phanerogamarum Monographiae...Dr. Richard P. Papp* joined the Department of Entomology of the Bishop Museum as of July 1 as Field Entomologist. Dr. Papp will be based in Hilo, working on the 'ohi'a dieback project under a research agreement with the U.S. Forest Service. Their expanded integrated study of this serious decline in Hawaii's forests is an extension of contractual work, on the entomological aspects of which *Dr. J. Linsley Gressitt* and *Dr. G. Allan Samuelson* have been the principal investigators. Drs. Gressit and Samuelson will continue to coordinate the Museum's work under the research agreement. Dr. Papp recently received his doctorate from the University of California at Berkeley....The annual Seminar at the University of Papua New Guinea, Port Moresby, was held May 2-7, on the theme "The Melanesian Environment: Change and Development." *Mr. D. E. Yen,* Ethnobotanist at Bishop Museum, was an invited speaker on "Decisions for the Commercialization of Agriculture," and with Dr. Harold C. Brookfield, Chief Technical Advisor, UNESCO-UNFPA Project, Fiji, produced the summary statements for the Seminar...As a result of a recent organizational meeting held at the Bishop Museum, *Dr. Roland W. Force* was named Chairman of Project 7 (Island Eco-Systems) of the UNESCO-sponsored "Man and the Biosphere Program." He is to serve on the U.S. National Committee for Man and the Biosphere, and attended its first meeting in Washington, D. C., on June 17 and 18. Under this project, Bishop Museum is collaborating closely with the University of Hawaii, the Smithsonian Institution, and other scientific institutions.......*Susan N. Kunisaki,* Area Identifier-Pathologist in Plant Protection and Quarantine, U.S. Department of Agriculture, was recently named one of the five outstanding women in Plant Protection and Quarantine as part of the APHIS observance of International Women's Year. The recognition is based on her outstanding performance of duties during the past 8 years. Susan is the first woman Area Identifier-Pathologist in PPQ.....Enclosed with this isuse are wallet-sized cards, "This is Orange Spiny Whitefly." Retain this card for future reference. The orange spiny whitefly is a very destructive and economically significant pest. For this reason, movement of roses, one of its hosts, is not permitted to the outer islands or the continental U.S.

Contributions from O. & I. Degener, W. Gagné, S. Sato, S. H. Sohmer, D. Spargo.

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
C/O DEPARTMENT OF BOTANY,
UNIVERSITY OF HAWAII,
HONOLULU, HAWAII 96822

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Newsletter Hawaiian Botanical Society

Contents

VOLUME 14 NUMBER 5 DECEMBER 1975

VEGETATION OF THE HAWAIIAN ISLANDS
by RÜdiger Knapp
and translated by Alvin Y. Yoshinaga and
Hugh H. Iltis 95

BRIEF REPORTS AND NOTES

EDITORIAL . . . .121; SOCIETY BUSINESS . . . .122, 123.

* * *

Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

Vegetationsmonographien der einzelnen Großräume

Herausgegeben von Prof. Dr. H. Walter, Stuttgart

Band I · Knapp

Die Vegetation von Nord- und Mittelamerika

und der Hawaii-Inseln · The Vegetation of North and Central America and of the Hawaiian Islands. 1965. XL, 373 S., 169 Abb., 335 Tab. und Pflanzenarten-Listen. Gzl. DM 88,–
Vorwort, Einführung und Inhaltsverzeichnis in deutscher und englischer Sprache

Band II · Hueck

Die Wälder Südamerikas

Ökologie, Zusammensetzung und wirtschaftliche Bedeutung. 1966. XX, 422 S., 253 Abb., Gzl. DM 90,–
In deutscher Sprache mit englischer Zusammenfassung

Band II a · Hueck/Seibert

Vegetationskarte von Südamerika · Mapa de la Vegetacion de America del Sur

Mit Erläuterungen. 1972. VIII, 71 S. zweisprachiger Erläuterungstext (deutsch-spanisch), eine mehrfarbige Karte, Format 74×105 cm, Maßstab 1:8 Mill., kart. cplt. DM 28,–

Band III · Knapp

Die Vegetation von Afrika

unter Berücksichtigung von Umwelt, Entwicklung, Wirtschaft, Agrar- und Forstgeographie. 1973. XLIV, 626 S., 823 Abb., 825 Tab. und Pflanzenarten-Listen, Gzl. DM 238,–
Vorwort, Einführung und Inhaltsverzeichnis in deutscher und englischer Sprache.

Band VII · Walter

Die Vegetation Osteuropas, Nord- und Zentralasiens

1974. XII, 452 S., 363 Abb., Gzl. DM 149,–

Band X · Walter

Klimadiagramm-Karten

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VEGETATION OF THE HAWAIIAN ISLANDS[1]

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Page
1. Development of the Indigenous Flora of the Hawaiian Islands. . . . 98
2. Tropical, Predominantly Montane Rain Forests of the Hawaiian Islands 100
3. Original Tropical Xeric Woodlands of the Hawaiian Islands. 102
4. Dwarf Shrub Heather and Heath Forests of Hawaiian Mountains. . . .103
5. Open Low Shrub and Cushion Plant Communities of the Highest Hawaiian Mountain Areas. 103
6. Bog Vegetation of the Cool and Most Humid Areas of the Hawaiian Islands 104
7. Woodless Vegetation of Dry Sites in the Hawaiian Islands 104
    a) Rock Crevice Vegetation with Small Ferns. 104
    b) Communities with Predominantly Annual Plants of Hot Arid Regions. 104
8. Cliff Coast Vegetation of the Hawaiian Islands 104
9. Strand Vegetation of the Hawaiian Islands. 105
    a) Coastal Dune Vegetation .105
    b) Low Shrub Vegetation of Sand Beaches. 105
10. Changes in the Vegetation Following the Settlement of the Hawaiian Islands by Polynesians and the Consequently Developed Plant Communities. .106
    a) Secondary Rain Forests 107
    b) Pili Grasslands 108
11. Changes in the Vegetation Since the Discovery of the Hawaiian Islands by Europeans and Plant Communities Developed as a Consequence of these Changes 109
    a) Algaroba Xeric Woodlands. 110
    b) *Leucaena glauca* Thickets. 110
    c) Xeric Low Shrub Communities 111
    d) Herb-Rich Vegetation of Forest Openings 112

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[1] This originally appeared as Chapter 10 of R. Knapp. 1965. *Die Vegetation von Nord- und Mittelamerika und der Hawaii-Inseln.* Stuttgart: Gustav Fischer Verlag. Publication of this translation kindly authorized by the author and the publisher. Translation has been kept as close to the German as possible.

Page
e) Predominantly Mesophilous Grasslands of Low and Intermediate Elevations. 112
f) Mountain Grasslands 113
g) *Chloris* Grasslands. 113
h) Salt Marsh and Mangrove Vegetation on Muddy Coasts. 114
12. Vegetation Zones in the Hawaiian Islands. 114
13. Literature on the Vegetation of the Hawaiian Islands 117
14. Knapp's Plant Nomenclature Updated (by Derral Herbst). 118

The Hawaiian Islands consist of eight main islands with 40 volcanoes which, however, are extinct for the most part. These islands originated since the Tertiary through volcanic activity. Corals played an important part in building a number of other smaller, mostly uninhabited islands. The great distance of the Hawaiian Islands to the nearest other islands and to the continents is noteworthy. For example, to the coast of the American continent and to Samoa, the nearest island group with mountains over 500 m high, is in both cases over 3000 km.

The climate varies greatly within the smallest areas. Because of the great altitudinal differences one may find, relatively close to rain forests of tropical character, regions in which tree growth is impossible due to lack of warmth and where in places snow can lie even in the summer. The highest mountains are well over 4000 m high (Mauna Loa 4170 m, Mauna Kea 4214 m). As a result of the mountainous terrain the precipitation is very variable also. Northeast winds (northeast trades) predominate decidedly, while west and southwest winds (Kona winds) are, in contrast, of much less significance. The low and middle elevations of the northeast sides of the islands and some areas on the west coasts thus often have especially wet climates.

The largest amounts of rain are usually found in the middle elevations. The highest annual precipitations, which are among the heaviest in the world (over 11,400 mm), were recorded on Kauai. The largest mountains are more-or-less cone-shaped volcanic peaks which often rise significantly above the cloud layers. The currents of moist air usually flow around them, and therefore they are drier than many lower-lying regions. Nevertheless the regions with the most pronounced aridity (lowest average annual rainfall less than 300 mm) occur in the rain shadows in the southwestern parts of the islands.

A map of the average annual precipitation for the island of Hawaii (Fig. 153) demonstrates how rainfall conditions of the different parts of an island may vary.

Climatic data for the stations Honolulu (Oahu, hot dry zones, not extreme) and Hilo (Hawaii, lower rain forest zones) can give an idea of the climates predominating at the lower elevations.

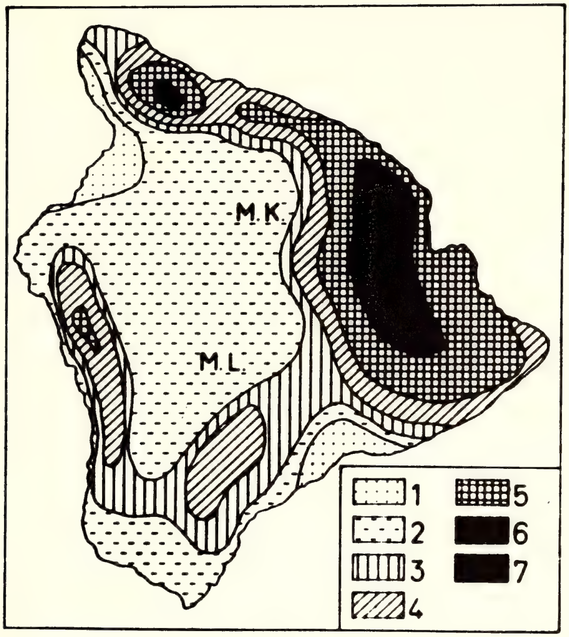

FIGURE 153. Average annual precipitation on the island of Hawaii. 1. Less than 508 mm. 2. 508-1016 mm. 3. 1016-1524 mm. 4. 1524-2540 mm. 5. 2540-4572 mm. 6. 4572-6092 mm. 7. Over 6092 mm. after FELDWISCH (1939), redrawn (originally in inches). M.K. = Mauna Kea. M.L. = Mauna Loa. Scale as in Fig. 169

	AVG. TEMP. (°C)			AVG. YEARLY PRECIPITATION (mm)	DRY MONTHS[2]	DROUGHT MONTHS[2]	ALMOST RAINLESS MONTHS[2]
	Year	Jan.	July				
Honolulu	23.3	21.3	25.0	703	7SpSuAu	6	---
Hilo	22.3	20.9	23.3	3687	---	---	---

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[2] (Legend from pp. 156-157 of the original text. Transl. note)

(con't. on p. 98)

The parent material for soil formation is predominantly of recent volcanic origin. As a result of the different climates, very diverse soil types have arisen. Red or brownish-red soils are widespread. Furthermore, soils derived from coral occur in regions near the coast, in relatively restricted distribution.

1. DEVELOPMENT OF THE INDIGENOUS FLORA OF THE HAWAIIAN ISLANDS

Since the assumption of any kind of land bridges to neighboring continents or larger island groups causes difficulties, the immigration of the forms ancestral to the species of the indigenous flora is an interesting problem. According to certain conjectures, seeds, spores and other propagules reached the Hawaiian Islands predominantly by means of storms and ocean currents. They could also have been brought there by birds. However, the relative species-poorness of the indigenous coastal flora speaks against the importance of ocean currents. Hence, other theories concerning the immigration of the Hawaiian flora have also been developed. The relationships of the Hawaiian flora are more clearly judged on the grounds of its more-or-less strong affinities to those of other lands. According to Fosberg (1948), of the ancestral species of the Hawaiian indigenous angiosperm flora, 40.1% were of Paleotropic (Indo-Pacific) origin, 16.5% Antarctic or Austral origin, 18.3% American (especially Neotropical) origin, and 2.6% Boreal (Holarctic, with the exception of American Holarctic forms) origin. The remaining ancestral forms are of Pantropic, cosmopolitan, or obscure origin. According to this, then, most of the ancestral forms immigrated from a westerly or southwesterly direction (Paleotropical elements). Nevertheless, even this group includes fewer than half of the ancestral forms. Immigrants from other directions are likewise very significant. The indigenous flora of the Hawaiian Islands is thus derived from elements of four floral kingdoms, of which those of the Paleotropic are most strongly represented. If one estimates the probable time elapsed since the first part of the Islands rose above the surface of the Pacific Ocean and compares this with the estimated number of conjectured ancestral forms on the basis of the modern extant flora, one finds that a successful establishment of a new angiosperm

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[2] (con't.)

Dry months: Number of months in which the average precipitation in mm is not greater than three times the average temperature above 0°C. The letters show the seasons in which the dry months occur: Su = summer (Jun-Aug); Au = autumn (Sep-Nov); Wi = winter (Dec-Feb); Sp = spring (Mar-May).

Drought Months: Number of months in which the average precipitation is not greater than double the average temperature, according to the relation given in the explanation for Dry Months.

Almost rainless months: Number of months with less than 10 mm precipitation and average temperature above 0°C.

species must have occurred on the average of once every 20,000 to 30,000 years.

Often several to many modern species may have evolved from one conjuectured ancestral form. Such profuse speciation was, and still is, highly favored by the diversity of the climate and habitat conditions in the Hawaiian Islands. Mutations which in certain ways could thrive better on particular habitats than could the original forms were thus in a position to spread and become successful. The diversity of environmental conditions and the separation of the individual islands by the ocean result in specific habitat conditions occurring only in comparatively small areas, with the same kind of habitat able to reoccur again, if at all, only at a considerable distance. This favors isolation and segregated evolution of species populations which can live only under these particular habitat conditions. Such conditions occur, for example, in genera whose forms are tied to the particular biotopes occurring in the narrow gorges in the rain forest zone, as, for example, in the genus *Cyrtandra* (Gesneriaceae).

As a consequence of the active volcanism, new areas, unoccupied by plants, were continually created. There, any possible mutants which could grow there especially well could become established. Competition with an already established vegetation cover did not impede their growth opportunities there. In places, lava flows isolated areas that were overgrown with dense vegetation. On these islands of old vegetation (*kipuka*) a continuing evolution in isolation of populations with comparatively few individuals was possible.

The fauna contributed also to the evolution of the distinctive character of the flora. Insects and birds (in particular the interesting family Drepanididae) were originally present in abundance. Plant species which were pollinated by insects and especially by birds could thus evolve in great diversity. On the other hand, large mammals were originally wholly lacking. Thus, until the immigration of man, the flora developed wholly without the influence of large grazing animals.

The proportion of the indigenous species present before human settlement which grow only in the Hawaiian Islands (endemics of the Hawaiian Islands) is extraordinarily high. Among the species and varieties of seed plants (of which only angiosperms were present), the proportion is 94.5%; among ferns and fern allies (pteridophytes), 64.9%.

It is above all noteworthy that a considerable number of genera are endemic to the Hawaiian Islands. Most significant are those of the Lobeliaceae (*Brighamia, Clermontia, Cyanea, Delissea, Rollandia, Trematolobelia*). Of the 521 Lobeliaceae (species and varieties), 150 are endemic to the Hawaiian Islands (Good 1951). Other families with several genera endemic to the Islands are the Compositae (e.g., *Raillardia**, *Argyroxiphium, Tetramolopium, Dubautia,* etc. and the Rubiaceae (e.g., *Kadua**, *Bobea,*

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* Updated nomenclature for taxa indicated by an asterisk will be found in Section 14, p. 118.

*Gouldia, Straussia**). Several examples of further Hawaiian endemic genera from other families are *Schiedea* (Caryophyllaceae), *Labordea**(Loganiaceae), *Stenogyne* (Labiatae) and *Nothocestrum*.

Most of the endemic species are shrubs or small trees.

Questions of the evolution of the vegetation of the Hawaiian Islands were also investigated with pollen analytical methods by Selling (1948, 1951).

2. TROPICAL, PREDOMINANTLY MONTANE RAIN FORESTS OF THE HAWAIIAN ISLANDS

The tropical wet forests of the Hawaiian Islands are evergreen and usually consist of several tree and shrub layers. The tallest trees are of moderate to low stature. They are seldom more than 15 m tall. The trunks are often relatively crooked and have abundant lateral branches. Most of the species have medium-sized leaves with more-or-less entire margins. Among them, however, grow tree ferns with gigantic fronds and lobeliads with very large leaves. Palms (*Pritchardia* spp.) occur only sporadically. In some places, lianas may penetrate the branches of the tree layer in considerable quantity; they are nevertheless not very richly represented (*Freycinetia, Alyxia, Strongylodon,* etc.). Under optimal development there is a wealth of woody species. Many of the species living in these forests occur on only one of the islands or even on just part of an island. Aside from the epiphytes, the forests consist mainly of phanerophytes. A true herb layer is usually only sparsely developed in undisturbed stands. *Metrosideros collina* (Polynesian name: 'Ōhi'a*; blossoms: Lehua) is an especially common dominant. Today these forests occur mainly from 600 m to 1700 m elevation in regions with an average yearly precipitation from 2000 mm to 10,000 mm. At lower elevations, where, under suitable habitat conditions, they could have originally covered large areas, particularly those with heavy rainfall, they survive today mostly only as remnants. At present, they are replaced mainly by secondary rain forests insofar as the particular areas are not used for agriculture. In the indigenous rain forests of the Hawaiian Islands, species from groups with Indo-Malaysian (Paleotropical) distribution centers play a particularly large role.

The soils in their typical development belong mainly to the latosols (Hydrol Humic Latosols, in part also Humic Latosols, among others; Ayres 1943, Matsusaka and Sherman 1950). They have in the upper layers a relatively high content of organic matter (usually 10-35%). Beneath an often dark brown horizon there usually follow yellow-red to red-brown plastic colors. These soils are acid to strongly acid (pH usually 4.5-6.0).

DD *Metrosideros collina* ssp. *polymorpha* (Myrtaceae), D *Acacia koa,* D † *Bobea elatior* (Rubiaceae)*, D † *Cibotium chamissoi**, † *Cheirodendron gaudichaudii* (Araliaceae)*, † *Cibotium splendens,* † *Clermontia* div. spec. (Lobeliaceae), † *Cyanea* div. spec. (Lobeliaceae), † *Cyrtandra* div. spec., † *Gouldia* div. spec. (Rubiaceae), † *Hibiscus arnottianus,* † *Osmanthus sandwicensis,* † *Pelea* div. spec. (Rutaceae), † *Phyllostegia* div. spec.

(Labiatae), † *Pipturus albidus* (Urticaceae), † *Pittosporum* div. spec., † *Pritchardia* div. spec. (Palmae), D *Freycinetia arborea* (Pandanaceae), *Alyxia olivaeformis* (Apocynaceae), † *Strongylodon lucidum* (Papilionaceae)*, † *Athyrium sandwichianum, Sadleria cyatheoides* (Polypodiaceae)*[3].

On the branches and trunks in these rain forests there can be thick stands of epiphytes, among which ferns and mosses play the main role. By far the largest number of the species named in the following list belong to the ferns. The relationships between the tree layers and shrub layers and the epiphytic vegetation is relatively close. For example, seedlings and young plants of the woody species often live as epiphytes.

† *Astelia menziesiana* (Liliaceae), † *Peperomia reflexa**, † *Peperomia* div. spec., † *Amphoradenium hymenophylloides**, † *Amphoradenium tamariscinum**, † *Asplenium nidus*, † *Elaphoglossum hirtum*, † *Elaphoglossum reticulatum**, † *Grammitis tenella*, † *Hymenophyllum lanceolatum**, † *Hymenophyllum obstusum**, † *Lycopodium nutans*, † *Ophioglossum pendulum* ssp. *falcatum*, † *Pleopeltis thunbergina**, † *Psilotum complanatum, Psilotum nudum*, † *Trichomanes davallioides**, † *Vittaria rigida*, † *Xiphopteris saffordii, Macromitrium piliferum, Rhizogonium spiniforme* †) = also occurring in corresponding communities outside of the Hawaiian Islands.

In gorges and similar places of areas covered by rain forest, plant communities of large perennial herbs occur in more-or-less open spots. Among their characteristic plant species are various species of *Gunnera* and the begoniaceous *Hillebrandia sandwicensis*.

Particularly in the drier parts of the rain forest zones there occur thick extended fern stands, up to 4 m high, with *Gleichenia linearis** dominating. They are capable of rapid spreading, especially after disturbance of the forest vegetation.

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[3] The lists of species occurring in the groups of forest and woodland plant communities begin mostly with tree species, are continued by shrub species, and end mostly with species of the herb layers. In cases such plants are important on soil surfaces, mosses and lichens are the last species mentioned in the lists. Grasses (Gramineae), sedges and other Cyperaceae, when necessary also Juncaceae, are scheduled as first species in the lists of grasslands and physiognomically similar plant communities.

Species always or in many cases growing in the particular plant communities with high coverage or even as dominants are accentuated in the lists by the letter "D" (most important dominants sometimes "DD"). When the results available seemed to be sufficient for such a regional quantitative ordination, species in some way significant for groups of plant communities are marked by the symbol "†." This distinction of certain species is based on the field observations available. The species accentuated by the sign mentioned above are not thought in most cases to be confined in their distribution to the plant communities where they are listed. They can occur more-or-less frequently also in certain other vegetation.

In regions near the coast there occur forests with *Pandanus odoratissimus* as the dominant. Today, to a large extent, only occasional *Pandanus* plants mark the former range of this plant community.

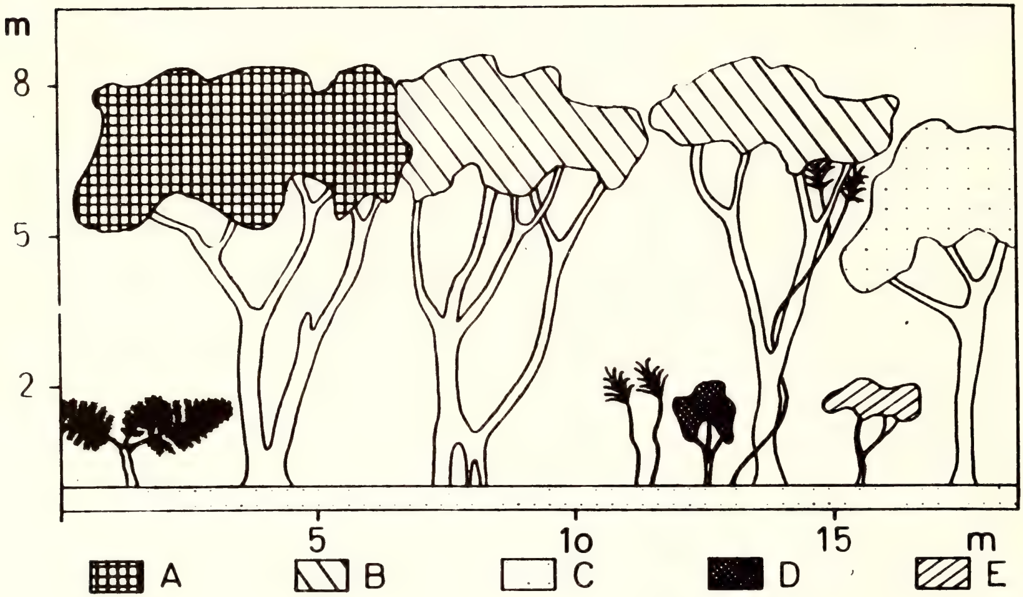

FIGURE 154. Diagrammatic Profile of an Evergreen Rain Forest of the Hawaiian Islands, Manoa district on Oahu. A = *Bobea elatior**. B = *Metrosideros collina* ssp. *polymorpha*. C = *Acacia koa*. D = *Pittosporum glabrum*. The tree fern at the left is *Cibotium chamissoi**. The liana or semi-liana in the middle right is *Freycinetia arborea*. An herb layer is for the most part absent. Even mosses do not grow on the forest floor. Original.

3. ORIGINAL TROPICAL XERIC WOODLANDS OF THE HAWAIIAN ISLANDS

The indigenous tropical xeric woodlands of the Hawaiian Islands consist to a large extent of deciduous species (*Erythrina, Reynoldsia*). However, evergreen woody species are usually mixed in. One deals thus with more-or-less semi-deciduous rain-green woodlands. The trees are usually of rather low stature. They seldom exceed 10 m in height. Some lianas occur (*Breweria**, *Canavalia, Cocculus*). Since human settlement, these plant communities are the ones that have been most extensively pushed back. Originally they were probably most typically developed in low elevation dry areas with average yearly rainfall of less than 1200 mm. Today they are mostly replaced by other plant communities consisting mainly of plants which were introduced since the discovery by Europeans.

D † *Erythrina sandwicensis*, D † *Reynoldsia sandwicensis* (Araliaceae), † *Acacia koaia*, † *Alphitonia ponderosa* (Rhamnaceae), † *Bobea sandwicensis*, † *Canthium odoratum* (Rubiaceae), † *Colubrina oppositifolia* (Rhamnaceae), † *Gossypium tomentosum**, † *Mezoneuron kavaiensis**, † *Neraudia melastomaefolia* (Urticaceae), † *Nesoluma polynesicum*, † *Santalum ellipticum*, † *Sapindus oahuensis*, *Dracaena aurea*, *Diospyros sandwicensis**, *Santalum freycinetianum*, *Breweria menziesii* (Convolvulaceae)*, *Canavalia galeata* (Papilionaceae), *Cocculus ferrandianus* (Menispermaceae).

4. DWARF SHRUB HEATHER AND HEATH FORESTS OF HAWAIIAN MOUNTAINS

The main distribution of these plant communities lies between 1600 m and 2500 m above sea level. On shallow soils and in regions with limited precipitation, however, they often descend down to lower elevations. Usually they occur under mean annual rainfalls between 750 and 1500 mm. They consist primarily of dwarf shrubs and other comparatively low, woody, small-leaved species. These plant communities are usually relatively species-poor. The high proportion of species belonging to groups having their main distributions in the Australian and south Pacific region is characteristic.

DD † *Styphelia tameiameae* (Epacridaceae)*, D † *Coprosma ernodecoides* (Rubiaceae)*, D † *Coprosma montana*, D † *Sophora chrysophylla* (Papilionaceae), D † *Vaccinium reticulatum*, D *Dodonaea viscosa* (Sapindaceae), D *Myoporum sandwicense* (Myoporaceae), † *Geranium tridens**, † *Raillardia laxiflora* (Compositae)*, † *Raillardia scabra**, † *Santalum haleakalae*, † *Vaccinium berberifolium*, † *Wikstroemia kilaueae* (Thymelaeaceae)*.

5. OPEN LOW SHRUB AND CUSHION PLANT COMMUNITIES OF THE HIGHEST HAWAIIAN MOUNTAIN AREAS

These very open plant communities occur at the highest elevations (mostly between 2500 m and 3400 m above sea level). The climate there is characterized by the frequency of frost fluctuations. Thus, even in summer, frosts are often an influence. The amount of precipitation is comparatively low (usually 750 mm-1250 mm yearly average). The plants live mainly on bare gravel, rock debris, and other undecomposed substrata. The proportion of cover is often only very low, so that from afar the areas frequently give an unvegetated impression.

Characteristic here is a relatively large proportion of species belonging to groups with primarily American distribution centers, or which presumably were derived from these.

† *Argyroxiphium sandwicense* (Compositae), † *Raillardia arborea* (Compositae)*, † *Raillardia menziesii**, † *Raillardia struthioloides**, † *Tetramolopium humile* (Compositae).

6. BOG VEGETATION OF THE COOL AND MOST HUMID AREAS OF THE HAWAIIAN ISLANDS

At high elevations, mostly above 600 m, bogs may develop, with appropriate substrate and under heavy precipitation (usually over 3000 mm yearly average). The plant communities there consist mainly of herbs, grasses, mosses, and low shrubs. Species which have their main distribution in other habitats appear here to some extent as dwarf forms, for example *Metrosideros collina* and *Styphelia tameiameae**. In the bog communities the proportion of species from groups with predominantly Antarctic main distributions is relatively high. In these Hawaiian bogs detailed pollen analysis investigations were carried out (Selling 1948).

† *Acaena exigua*, † *Exocarpus luteolus* (Loranthaceae)*, † *Lagenophora mauiensis* (Compositae)*, † *Oreobolus furcatus* (Cyperaceae), † *Panicum imbricatum*, † *Panicum isachnoides**, † *Panicum monticola**, † *Viola kauaiensis**, † *Viola mauiensis**, *Drosera longifolia**, *Rhynchospora* div. spec., *Sphagnum* div. spec.

7. WOODLESS VEGETATION OF DRY SITES IN THE HAWAIIAN ISLANDS

a) Rock Crevice Vegetation with Small Ferns

These plant communities consist mainly of small ferns, which have the ability to withstand extensive drying, in rock crevices. They usually form very open communities.

† *Doryopteris decora*, † *Pellaea tenuifolia**, † *Asplenium unilaterale*, *Asplenium adiantum-nigrum*, *Asplenium trichomanes*, *Psilotum nudum*.

b) Communities of Predominantly Annual Plants of Hot Arid Regions

Primarily in the driest regions, usually near the coast, certain plant communities consisting mainly of annual species were able to evolve. Presumably, they spread widely into places where the xeric woodland vegetation was pushed back after the immigration of the Polynesians. Presently, they have been very widely displaced by plant communities consisting of introduced species. The stands still persisting today have mostly been similarly invaded by species introduced since the 19th century.

† *Panicum torridum*, † *Panicum cinereum**, † *Centaurium sebaeoides*, † *Argemone alba* var. *glauca**.

8. CLIFF COAST VEGETATION OF THE HAWAIIAN ISLANDS

These very open plant communities can colonize rocky sea coasts. In these, species with low-lying shoots pressed against the ground play a large role. The plants often root in rock crevices or heaps of rock debris. These communities usually live under extreme influence of wind. The influence of atomized salty ocean water (salt spray) is very significant. As a result of the heavy surf, these cliff coast communities can at times occur up to an elevation of 130 m above sea level.

† *Abutilon incanum*, † *Capparis sandwichiana*, † *Jacquemontia sandwicensis* (Convolvulaceae), † *Lipochaeta calycosa* (Compositae)*, † *Lipochaeta integrifolia*, † *Lipochaeta succulenta* var. *decurrens*, † *Lycium sandwicense*, † *Portulaca lutea*, † *Sesbania tomentosa* (Papilionaceae), *Atriplex semibaccata*, *Lipochaeta lobata*.

9. STRAND VEGETATION OF THE HAWAIIAN ISLANDS

Distinctive plant communities grow on the locally rather extensive sand strand areas on the coasts of the Hawaiian Islands.

a) Coastal Dune Vegetation

On the loose, wind-blown dune sand of the coasts occur plant communities which are usually open and species-poor. The plants composing them are, however, sometimes very striking. They creep over the sand, with the long shoots usually lying closely appressed to the surface of the ground.

D †) *Ipomoea pes-caprae*, † *Nama sandwicense* (Hydrophyllaceae)*, †) *Tribulus cistoides*, †) *Vigna marina*, *Cuscuta sandwichiana*.

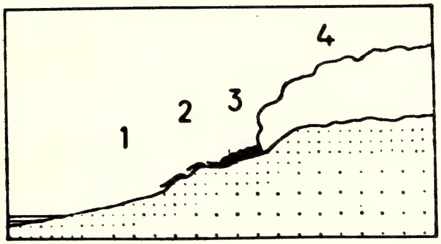

FIGURE 155. Vegetation profile of the sand strand on the seacoast of Maui, near Kahului. To the right, south; to the left, north. 1. Unvegetated sand strand. 2. Coastal dune community with *Ipomoea pes-caprae* dominant. At the time of the investigation the first *Ipomoea* plants were 1.6 m above sea level. 3. Low shrub community of sand beaches, with *Scaevola frutescens** dominant (first plants, 3 m above sea level). 4. Secondary algaroba xeric woodland (*Prosopis chilensis** dominant, from 3.5 m above sea level). Original.

b) Low Shrub Vegetation of Sand Beaches

On the sand beaches of the Hawaiian Islands the low shrub vegetation is physiognomically quite striking. However, it consists of only a few

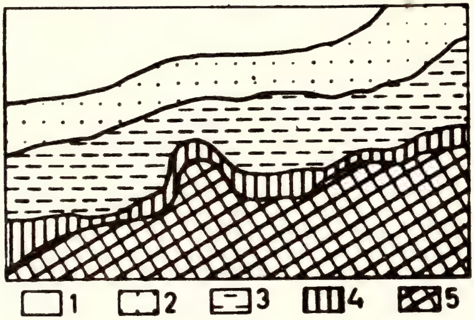

FIGURE 156. Example of a vegetation map for the locality treated by the previous figure (Figure 155). Vertical axis of the map, 50 m. 1. Ocean. 2. (dotted) Unvegetated sand strand. 3. (horizontal broken lines) Coastal dune community with *Ipomea pes-caprae*. 4. (vertical lines) Low shrub community with *Scaevola frutescens**. 5. (diagonal cross hatching) Algaroba xeric woodland. Original.

species. Often, only the goodeniaceous *Scaevola frutescens** occurs there. The shrubs are rather dense, yet low. They often form a belt behind the previously discussed plant communities, which consist mostly of herbs. Not infrequently, they can establish themselves on sites previously occupied by the latter, if the sand has been consolidated to a certain degree.

D †) *Scaevola frutescens**, *Vitex trifolia* var. *simplicifolia**.

10. CHANGES IN THE VEGETATION FOLLOWING THE SETTLEMENT OF THE HAWAIIAN ISLANDS BY THE POLYNESIANS AND THE CONSEQUENTLY DEVELOPED PLANT COMMUNITIES

The Hawaiian Islands were settled by humans comparatively recently. The immigration of the Polynesians presumably occurred since approximately 500 AD in several, and to all appearances two, main waves. The number of Polynesian inhabitants who lived on the Islands at the time of the discovery by Cook in 1778 is estimated at 300,000. The present population consists of over 500,000, thus about 30 per sq. km. Of these, more than half live in the capital city, Honolulu, itself. Thus, in rural districts, the population density today is often less than it was at the time of Cook's discovery of the Islands. The Polynesians lived mostly in the regions closest to the coast. There, because of the high population density, their influence on the vegetation must have been very profound. Using digging-stick agriculture they planted mostly large amounts of taro (*Colocasia esculenta*), bananas (Polynesian-Hawaiian name: Maia*) and sweet potatoes (uala*, *Ipomoea batatas*). About 200 old Polynesian localities have become known in the Hawaiian Islands for taro, about 50 for bananas. Yams *(Dioscorea)* and *Tacca pinnatifida** were less significant as starch-supplying cultivated plants. The Polynesians also brought sugar cane to Hawaii. Among other introduced plants besides these were various trees, e.g., breadfruit (ulu*, *Artocarpus communis = incisa**), or species suitable for production of bark-clothing (kapa), e.g., wauke, *Broussonetia papyrifera*. Coconut palms were also rather ancient crop plants in the Hawaiian Islands, even though there they did not have the eminent importance they did in certain more southerly Polynesian island groups.

The original vegetation disappeared in the actual cultivated areas. Beyond that, a number of cultivated plants introduced by the Polynesians escaped into the wild. In certain of these cases it is difficult to decide whether a species was originally native to the Hawaiian Islands or was able to become established only after introduction by the Polynesians. Under the influences of plant introductions and as a result of the disturbance of the native stands, secondary rain forests developed at lower elevations. In this context it must be noted that the Polynesians also used numerous species of the native flora in the most diverse ways, including the algae of the sea coasts (limu). For many of them special Polynesian names exist.

The Polynesians brought only a relatively few domestic animals with them. Of the larger grazing animals, they introduced only pigs. In the dry areas, the vegetation in addition was surely influenced strongly by intentionally or accidentally started fires. Through this, certain grassy areas were much favored at the expense of woodland.

a) Secondary Rain Forests

The secondary rain forests, too, are evergreen and of moderate height. In contrast to the original rain forests, they are, however, often bushy and rich in shrubs, and the herb layer is usually thick and well-expressed. Today the secondary rain forests are distributed mainly between 150 m and 600 m. In the areas of heaviest rainfall, however, they come down as far as the coastal regions. Usually, they occur under average yearly rainfalls of 2000 mm to 4500 mm. They are relatively species-poor. However, through new introductions the number of species seems to be gradually and constantly increasing. Species introduced by the Polynesians are important. However, species which have become established in the Hawaiian Islands since the 19th century are richly represented. In addition, some species originally native to the Islands can persist in these communities.

DD †) *Aleurites mollucana**, DD †) *Psidium guajava*, D †) *Calophyllum inophyllum*, D † *Psidium cattleianum* var. *citrinum**, D *Coffea arabica*, D *Hibiscus tiliaceus*, †) *Bambusa vulgaris*, †) *Jambosa jambos**, *Acacia koa*, *Musa sapientum**, *Schinus terebinthifolius*, D †) *Cordyline terminalis*, *Freycinetia arborea*, D †) *Hedychium flavum**, D *Setaria palmifolia*, †) *Zingiber zerumbet*, *Hedychium coronarium*, *Oxalis martiana*.

In the species list above, and in the following species lists of Sections 10 and 11, the species characteristic to particular groups of plant communities of the Hawaiian Islands are distinguished with the symbol "†)." In other regions and other parts of the world these species can occur frequently in other plant communities.

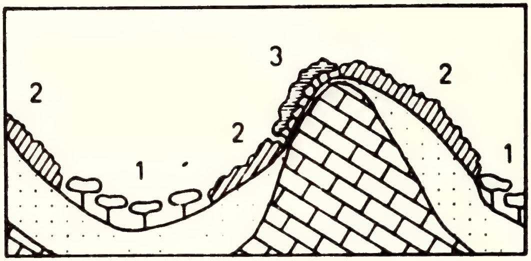

FIGURE 157. Vegetation profile of an area covered primarily by secondary rain forest, from the southwest part of the Koolau Range on Oahu. 1. Forest dominated by *Aleurites mollucana**. 2. Scrub thicket dominated by guava (*Psidium guajava*). 3. Remnants of the original evergreen rain forest on thin soil, dominated by *Metrosideros collina* ssp. *polymorpha*.

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b) Pili Grasslands

These grassland communities presumably expanded vigorously at the cost of the xeric woodlands following the Polynesian settlement, or they possibly originated first at that time. Pili grass (*Heteropogon contortus*) was used by the Polynesians in various ways, for example in building huts. Pili grasslands prefer low elevation, hot, dry regions. Today these have been for the most part greatly changed as a result of overgrazing and other influences, and have largely been pushed back by species which came in since the 19th century and by the communities which arose from them. At present, and not infrequently, a considerable intermeshing with and penetration by xeric shrub communities may be observed (section 11c).

D † *Heteropogon contortus*, *Cenchrus calyculatus**, *Cenchrus pedunculatus**, *Chrysopogon aciculatus*, *Eragrostis variabilis*, *Stenotaphrum americanum**, *Tephrosia purpurea*.

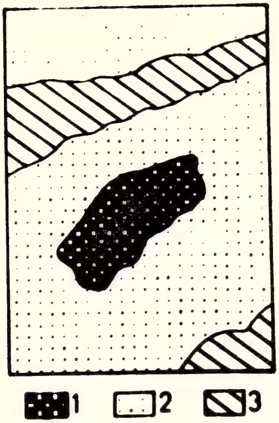


FIGURE 158. Example of a vegetation map from the area treated in the previous figure (Fig. 157). Vertical axis of the map section, 300 m. 1. (Checkerboard) *Metrosideros collina* forest. 2. (dotted) Guava scrub thicket (*Psidium guajava*). 3. (diagonal lines) *Aleurites mollucana** forest.

11. CHANGES IN THE VEGETATION SINCE THE DISCOVERY OF THE HAWAIIAN ISLANDS BY EUROPEANS AND PLANT COMMUNITIES DEVELOPED AS A CONSEQUENCE OF THESE CHANGES

Shortly after the discovery of the Islands (1778), cattle, horses, sheep and goats were introduced. These very soon became feral and multiplied rapidly, since no natural enemies were present. They spread over large parts of the Islands. Grazing by these animals had a most pronounced influence on the lower, not extremely wet areas. The indigenous vegetation, which had evolved without the influence of large grazing animals, was extremely heavily damaged. This effect had further consequences through yet another process which began after the discovery. Besides the cultivated plants, which are grown in fields and plantations, plant species were deliberately introduced or unintentionally brought in on a large scale from the most diverse parts of the world. To a large degree, these were better able to withstand the grazing pressure. Thus, they could replace the indigenous vegetation from extensive parts of the Islands.

At first only relatively slowly, later however rapidly and on a large scale, extensive areas have been converted since the discovery to plantings of tropical crop plants for export. Among these, sugar cane predominates in the lower, easily irrigated districts (1954: 220,138 acres, 5.3% of the total area, 72% of the cultivated area), and pineapples in somewhat higher regions (1954: 73,200 acres, 1.8% of the total area). Sugar cane and pineapples are usually grown in rather extensive, somewhat monotonous monoculture fields. Coffee (4320 acres, principally on the west side of the island of Hawaii, Kona District), and the proteaceous *Macadamia ternifolia** (2721 acres), whose nut-like fruits represent a lucrative export article, are arborescent crop plants which are grown widely, although over relatively small areas compared to those of the two previous species. In inhabited areas there are, in places, especially beautiful gardens with many tropical ornamental plants. They are especially famous for their orchid culture.

Since Cook's discovery, through changes in the plant and animal compliment of the Islands, numerous new plant communities have developed which presently are extremely widespread even outside agricultural areas. To these belong first of all a number of plant communities containing primarily introduced shrubs and trees which were especially able to invade the dry regions. Furthermore, especially in connection with grazing, a number of grass communities were able to develop. In open places annual species not previously represented in the Islands were able to spread and to form new vegetational units. Only through the introduction of particular species could mangrove communities develop on muddy coasts. In connection with intensive cultivation and fertilizing and the introduction of appropriate species, weed communities of predominantly annual species ultimately developed in gardens, fields, and plantations.

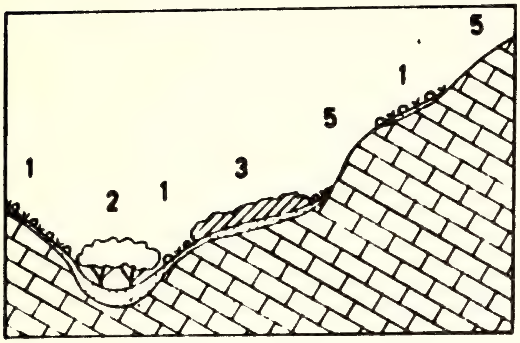
Therefore today, especially near inhabited areas and regions with roads, only sparse remains at most of the indigenous vegetation are to be seen. It is, however, still able to maintain itself in remote areas with high precipitation. However even in certain drier regions, the members of the indigenous flora have shown themselves to have adequate competitive ability against the introduced species. This is especially true for specific coastal regions and certain habitats with relatively thin soils on comparatively young volcanic deposits (e.g., Fig. 158).

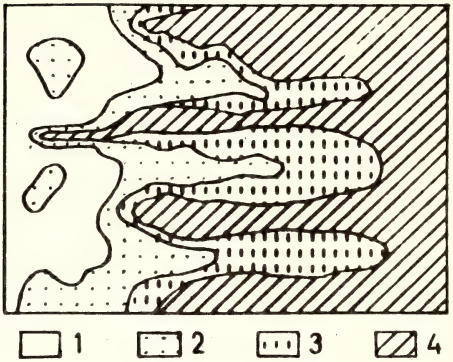
a) Algaroba (= kiawe) Xeric Woodlands

These xeric woodlands, consisting mainly of *Prosopis chilensis** (algaroba, kiawe), introduced in 1838, are extremely widespread today. They occur in low elevation, warm, dry areas, especially near the coast. Their main distribution ranges up to 300 m elevation. These plant communities are usually very species-poor. They consist almost entirely of species introduced since the 19th century. Only infrequently are species of the original xeric woodlands still extant.

b) *Leucaena glauca** (Koa haole) Thickets

These presently often very widely distributed thickets of *Leucaena glauca** (Koa haole) are also usually species-poor. They often have a dense well-developed herb layer. For good development, they require in





FIGURES 159 (Left) and 160 (Right) of Algaroba Xeric Woodland.

FIGURE 159. Vegetation profile near Koko Head, Oahu. 1. Xeric grasslands (*Chloris* grasslands, etc.), in part (below 3 and to the left above 2) intermingled with xeric low shrub communities. 2. Xeric woodland composed primarily of introduced species (mainly *Prosopis chilensis**), with elements of plants originally native to the Hawaiian Islands (e.g., *Erythrina sandwicensis*). 3. *Leucaena glauca** thicket. 5. Mostly unvegetated rock. In crevices, vegetation with small ferns, etc. Original.

FIGURE 160. Example of a vegetation map of the area treated in the previous figure (Fig. 159). Width of the map section, 200 m. 1. (blank) Bare rock and rock crevice vegetation. 2. (dotted) Xeric grasslands. 3. (broken lines) Xeric grasslands intermingled with xeric low shrub communities. 4. (diagonal lines) Shrubby xeric woodland with *Prosopis chilensis** and *Erythrina sandwicensis*. Original.

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general more moisture than the algaroba xeric woodlands. However their main distribution is also in low elevation, warm areas below 300 m.

D †) *Leucaena glauca**, D †) *Bryophyllum pinnatum**, D *Commelina diffusa*, D *Setaria palmifolia*, *Selenicereus grandiflorus*.

c) Xeric Low Shrub Communities

These low, usually more-or-less markedly open scrub communities of predominantly small shrubs are sometimes very extensive in low elevation areas with little rain. They occur mainly below 300 m. Certain development forms create the early stages of succession on fallow land. A continuing succession to algaroba and *Leucaena glauca** woodlands is possible. On thin-soiled rocky habitats and in certain very dry areas, particularly under the influence of certain kinds of use, xeric low shrub communities can form permanent communities in the Hawaiian Islands.

†) *Acacia farnesiana*, †) *Cassia bicapsularis*, †) *Cassia lechenaultiana**, †) *Crotalaria longirostrata*, †) *Phaseolus lathyroides*, †) *Pithecellobium dulce*, †) *Pluchea indica*, †) *Sida cordifolia*, †) *Sida fallax*, †) *Verbesina encelioides*, †) *Waltheria americana**, *Crotalaria saltiana**, *Desmodium triflorum*, *Indigofera suffruticosa*, *Lantana camara*, *Opuntia megacantha*, *Osteomeles anthyllidifolia*, *Stachytarpheta jamaicensis*.

d) Herb-Rich Vegetation of Forest Openings

Plant communities especially rich in herbs have developed primarily from introduced species in forest openings, cut-over areas, along more-or-less lightly shaded places along roads, forest trails, and similar places. They establish themselves in lower to middle elevations under medium to rather heavy precipitation regimes. They are especially well represented in the secondary rain forest zone.

†) *Adenostemma viscosum**, †) *Tithonia diversifolia* (Compositae), †) *Verononia cinerea*, *Ageratum conyzoides*, *Mimosa pudica*, *Paspalum conjugatum*, *Rubus rosaefolius*, *Spathoglottis plicata* (Orchidaceae), *Stachytarpheta jamaicensis*.

e) Predominantly Mesophilous Grasslands of Low and Intermediate Elevations

Anthropogenic grassland communities are most diversely developed in the lower and in part also in the intermediate elevations as a result of the most strong and varied economic influences in these zones. In dry areas they are often irrigated. To some extent they are more-or-less frequently cut or grazed. Compared to European or Mediterranean grasslands these plant communities are usually very species-poor.

Park Lawns of Sunny Low Elevation Locations

These park lawns occur in low areas with a hot climate, where the largest settlements are found. They are distributed there in gardens and parks. Under good care, they are cut frequently and, in dry times, watered. With adequate water supply, use for grazing is also possible. The plant communities need strong light and usually grow in full sun. Often the stands consist entirely of Gramineae.

†) *Digitaria henryi**, †) *Eremochloa ophiuroides*, †) *Stenotaphrum secundatum*, †) *Zoysia tenuifolia*, *Cymbopogon refractus*, *Cynodon dactylon*, *Paspalum dilatatum*, *Sporobolus indicus*.

Park Lawns of Shady Low Elevation Locations

The composition of lawns in shady locations is sharply distinguished from that of the communities characterized in the previous section. Lawns, mainly of *Cyperus*, grow under trees and other shady spots in low elevations in gardens and parks. They are usually cut less frequently and also form a lawn sod of lesser density than the park lawns of low elevation, sunny areas.

D †) *Cyperus gracilis*, †) *Cyperus kyllingia f. humilis*, *Centella asiatica*, *Oxalis corniculata*.

Grass Communities of Paths ("Stepped-On Lawns")

Along trail edges and small paths, a grass community may thrive in which *Eleusine indica* is dominant and characteristic. It usually grows in full sun and withstands frequent cutting.

*Tricholaena** Grasslands

Predominantly in regions of intermediate elevations and under intermediate precipitation there occurs a grass community in which *Tricholaena repens**, a grass striking for its long, silky-haired glumes and its rose-colored shoots, plays a large role. Often this grass community occurs between *Leucaena* thickets.

D †) *Tricholaena repens**, D *Trichachne insularis*, *Cynodon dactylon*.

Paspalum orbiculare Grasslands

Grass communities with *Paspalum orbiculare* dominant occur mostly at intermediate elevation locations with moderate to heavy precipitation. Sometimes it is a case of permanent communities used as pasture.

D †) *Paspalum orbiculare*, *Chrysopogon aciculatus*, *Paspalum conjugatum*, *Setaria geniculata*.

f) Mountain Grasslands

At high elevation locations one may now find mesophilous grasslands that consist to a great part of species which were introduced from Europe. However, native Hawaiian species can also be part of their composition. These grasslands, too, are still rather species-poor today. They, however, will presumably gradually become richer in species through continual new introductions. They arose in particular from the original dwarf shrub heather and heath forests after clearing and grazing. Their main distribution lies between 1600 m and 2500 m.

D †) *Anthoxanthum odoratum*, D †) *Sporobolus capensis**, D † *Deschampsia australis*, D †) *Holcus lanatus*, D † *Trisetum glomeratum*, *Eragrostis brownei*, *Eragrostis leptophylla*, *Hypochoeris radicata*, *Lucula campestris**, *Plantago lanceolata*, *Poa pratensis*.

g) *Chloris* Grasslands

Certain plant communities consisting primarily of introduced annual grasses occur in open sites in areas of lowest elevation and greatest aridity. They disappear as soon as the xeric woodland appropriate in these places develops.

D †) *Chloris inflata*, *Avena barbata*, *Cenchrus echinatus*, *Eragrostis amabilis**.

h) Salt Marsh and Mangrove Vegetation on Muddy Coasts

These usually rather dense, mostly herbaceous, species-poor plant communities usually occur on the sea coasts on muddy soils on substrata inundated by salt water. In these, *Batis maritima* is often dominant. This species, originally native to America, was first found in the Hawaiian Islands in 1859 by Hillebrand (1888) and has since spread widely.

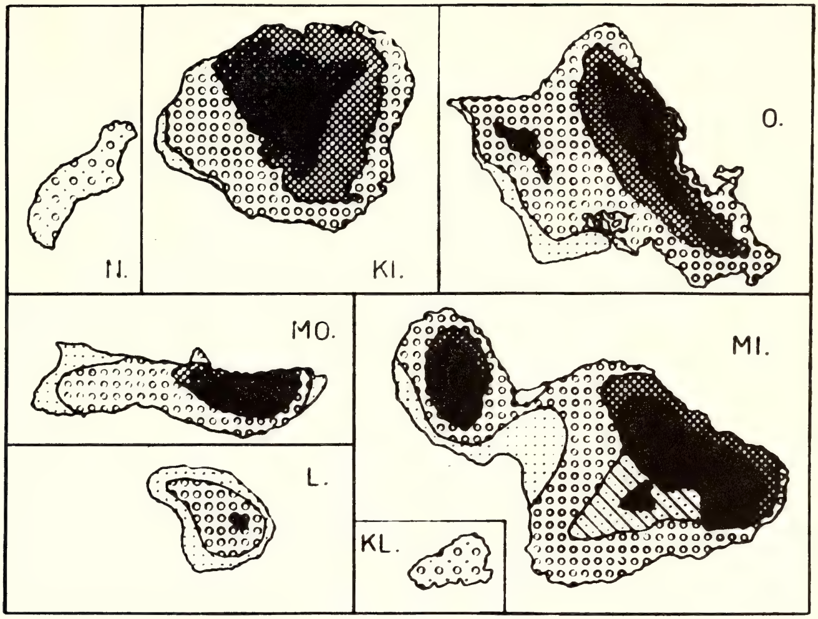
Mangrove thicket species were first introduced into the Hawaiian Islands after 1900 (*Bruguiera parviflora, Bruguiera sexangula**, *Rhizophora mangle*). They are presently expanding their range on the coasts and in places are occupying areas previously occupied by *Batis* communities.

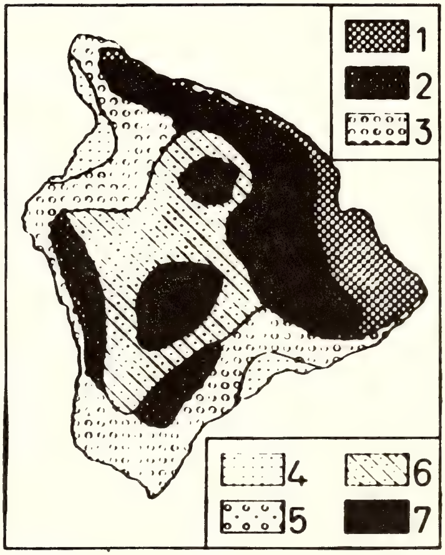
12. VEGETATION ZONES IN THE HAWAIIAN ISLANDS

The great diversity of the habitats in the Hawaiian Islands can be arranged into a series of vegetation zones (life zones, transl. note) which are always distinguished by the special significance of particular plant communities.

The rain forest zones are marked by a very moist climate (usually more than 2000 mm, however, especially in somewhat higher areas, as low as 1500 mm yearly average). As a result of heavy leaching, there is a tendency toward the formation of acid soils. According to the differentiating temperature regime and humidity of the climate, a subdivision into submontane and montane rain forest zones is noteworthy. The boundary region between these usually lies from 200 m to 600 m above sea level. In the more elevated regions the original rain forests are for the most part still preserved. To these may be added bog vegetation, which form natural communities, even though of restricted distribution. Cultivation of crop plants is usually not worthwhile here due to the low insolation and other unfavorable effects of the extremely humid climate. The warmer and less extremely wet submontane rain forest zones are in places relatively densely inhabited. Thus the original rain forests have been widely pushed back. They are replaced by secondary rain forests, by the likewise secondary herb-rich vegetation of forest openings, and above all, by areas utilized in agriculture. Moisture-requiring crop plants, e.g., taro, grow well. Sugar cane today often covers the most extensive areas; its sugar content is usually lower than in the past.

The hot dry zones occupy the drier regions of lower elevations. The dry season, when occasional rains also fall, occurs during the summer months (the driest month is usually June), through which their effect is amplified. The soils are naturally often neutral to weakly alkaline. Within the dry zones may be distinguished the very dry lowland zones usually with an annual precipitation of less than 500 mm. Today the indigenous tropical xeric woodlands (Section 3) have been almost entirely displaced. Between the immigration of the Polynesians and the discovery of the islands by Cook, pili grasslands (section 10b) and communities with predominantly annual plants of hot arid regions (Section 7b) probably spread out in their place. After Cook's discovery of the Islands, it was





FIGURES 161-168. Vegetation zones of the Hawaiian Islands. 1. (diagonal cross hatching) Submontane rain forest zone. 2. (checkerboard) Montane rain forest zone. 3. (circles) Moderately dry lowland zone (non-extreme regions). 4. (dotted) Very dry lowland zone. 5. (dotted, with circles) Hot dry zones, not classfied under 3 or 4. 6. (dotted, with diagonal cross hatching) Upper montane or subalpine zone. 7. (black) Alpine zone or cold desert zone. Explanations of the characteristics of the individual vegetation zones in the text. N, Niihau. KI, Kauai. O, Oahu. MO, Molokai. L, Lanai. MI, Maui. KL, Kahoolawe. Below, Hawaii, rather reduced. Scale for the other islands is uniform.

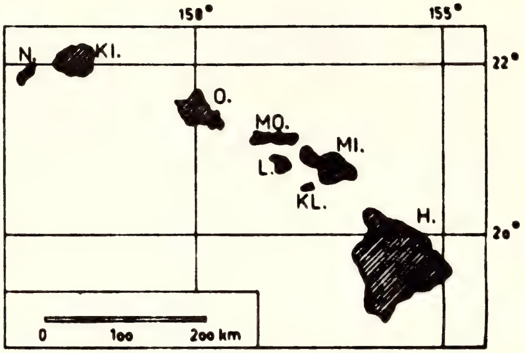


FIGURE 169. Overall map of the Hawaiian Islands. H, Hawaii, Other abbreviations as in Figs. 161-168.

precisely in this region that many plant communities consisting primarily or entirely of introduced species developed. Today they cover by far the largest area there. Regions where the rainfall is not extremely low, and in particular areas which have conditions favorable for irrigation, are especially well suited to the cultivation of many tropical crop plants. The warm sunny climate makes possible a high productivity of plants when an adequate water supply is made available. The water necessary for irrigation can often be brought in from the comparatively nearby rain forest areas. At present, the cultivation of pineapples and sugar cane is important here. Less intensively used areas in the dry regions serve today in part as grazing land (range management).

Above the previously named regions lie the upper montane or subalpine zones (usually between ca. 1500 m and 2700 m). Within them, the most widespread natural plant communities are dwarf shrub heather and heath forests of montane regions (Section 4). However, also in these cool areas, the original vegetation is to a considerable degree supplanted by plant communities consisting partly or entirely of introduced species. Among these, the mountain grasslands (Section 11f) are by far the most widespread. Part of the area in these vegetation zones is used for grazing.

Above these lie the zones of alpine (high mountain) vegetation. They are characterized above all by the very open low shrub and cushion plant communities of the highest mountain areas (Section 5). In addition, certain moss and lichen communities occur there.

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14. KNAPP'S PLANT NOMENCLATURE UPDATED (BY DERRAL HERBST, HAROLD L. LYON ARBORETUM)

Much additional information on the Hawaiian flora has accrued in the eleven years since *Die Vegetation von Nord- und Mittelamerika und der Hawaii-Inseln* first appeared. Before proceeding with the nomenclatural changes, however, a few observations may be in order.

I question some of Professor Knapp's statements as, for example, the choice of *Crotalaria longirostrata* as a species characteristic of xeric, low-shrub communities. *Crotalaria longirostrata* is a locally common, naturalized weed presently known from a small area near Ulupalakua, Maui. Perhaps another weedy *Crotalaria, C. incanum,* commonly found in the same environmental niche throughout the islands would better characterize this plant community.

Stachytarpheta jamaicensis appears on two of Knapp's species lists, but the more common *S. urticaefolia* is not mentioned. The two species occupy the same enviornmental niche, frequently grow intermixed, and are often misidentified. As no voucher specimens are cited, I could not check the identity of any of the species listed. In continental areas, some plants grow in very restricted areas--for example, certain species grow only on granite outcroppings, and can be used as indicators of that type of substraté. However our native plants usually are less specialized and our ubiquitous weeds certainly cannot be cited as indicators of very specialized environments. *Crotalaria longirostrata* would grow in many places on all the islands if someone would spread its seeds.

Professor Knapp, in the European style, usually cites rare plants as indicator species of a certain environment. But can one consider *Bonamia (Breweria)*, a rare plant, as characteristic of tropical xeric woodlands when it has been collected several times in wet forests? Statistically, I am sure one can, but the point is that I believe that it would be more logical to characterize an environmental niche by the plants that usually grow there than by the ones that rarely do. There are too many other factors involved with rare species.

However, the purpose of this addenda is not to review the article but rather to update its nomenclature. The following criteria govern the inclusion of items on the list:

1) Species previously misdetermined. Kiawe was originally identified as *Prosopis chilensis*, but further study has indicated that probably it is *Prosopis pallida*.

2) Nomenclatural and taxonomic changes. These are the changes of plant names based upon technical evaluations. For example, *Bobea elatior* is now called *Bobea gaudichaudii* because the specific name *gaudichaudii* was published one year before the name *elatior*; simply stated, older names according to the "International Code of Botanical Nomenclature" have priority over the ones published at a later date.

The endemic genus *Straussia*, of the coffee family, was studied by a specialist in that family; he concluded that the species of *Straussia* were not sufficiently different from those of the wide-spread genus *Psychotria* to maintain two separate genera. *Straussia* is now considered a section of the genus *Psychotria*.

3) Spelling errors. The hamza (') is very important in determining the pronunciation and the meaning of Hawaiian words; lacking this diacritical mark, the word is not spelled correctly. Obvious typographical errors as *Lucula* instead of *Luzula* are corrected.

4) Incorrect identifications. As no voucher specimens were cited, I have kept this section to a minimum; however, a few obvious errors are included. For example, the high elevation bog pūkiawe mentioned in text possibly could be *Styphelia tameiameiae* or, in the Alakai Swamp, a new variety of *S. tameiameiae*, but most growing in this environment would be *S. douglasii*.

The plant names marked with an asterisk in the text are listed alphabetically below. Their currently accepted equivalents are in italics. They are based upon the latest accepted information for each of the species and may change as a result of further studies.

Adenostemma viscosum = *A. lavenia* (L.) Ktze.

Aleurites mollucana = *A. moluccana* (L.) Willd.
Amphoradenium hymenophylloides = *Adenophorus hymenophylloides* (Kaulf.) Hook. & Grev.
Amphoradenium tamariscinum = *Adenophorus tamariscinus* (Kaulf.) Hook. & Grev.
Argemone alba var. glauca = *A. glauca* (Prain) Deg. & Deg.
Artocarpus communis = incisa = *A. altilis* (Parkins. ex Z) Fosb.
Bobea elatior = *B. gaudichaudii* (C. & S.) St. John & Herbst
Breweria = *Bonamia*
Breweria menziesii = *Bonamia menziesii* Gray
Bruguiera sexangula = *B. gymnorhiza* (L.) Lam.
Bryophyllum pinnatum = *Kalanchoe pinnata* (Lam.) Pers.
Cassia lechenaultiana = *C. leschenaultiana* DC.
Cenchrus calyculatus = *C. agrimonioides* Trin.
Cenchrus pedunculatus = *C. pedunculata* Deg. & Whitney
Cheirodendron gaudichaudii = *C. trigynum* (Gaud.) Heller
Cibotium chamissoi = *C. glaucum* (Sm.) H. & A., as concerns the Big Island plants; those on Oahu are best referred to *C. splendens* (Gaud.) Krajina.
Coprosma ernodecoides = *C. ernodeoides* Gray
Crotalaria saltiana = *C. pallida* Aiton
Digitaria henryi = *D. adscendens* (HBK.) Henr.
Diospyros sandwicensis = *D. ferrea* subsp. *sandwicensis* (A.DC.) Fosb.
Drosera longifolia = *D. anglica* Huds.
Elaphoglossum reticulatum = *E. crassifolium* (Gaud.) Anderson & Crosby
Eragrostis amabilis = *E. tenella* (L.) Beauv. ex R. & S.
Exocarpus luteolus (Loranthaceae) = *E. luteolus* (Santalaceae)
Geranium tridens = *G. cuneatum* var. *tridens* (Hbd.) Fosb.
Gleichenia linearis = *Dicranopteris linearis* var. *maxima* (Christ.) Deg. & Deg.
Gossypium tomentosum = *G. sandvicense* Parl.
Hedychium flavum = *H. flavescens* Carey
Hymenophyllum lanceolatum = *Sphaerocionium lanceolatum* (H. & A.) Copel.
Hymenophyllum obtusum = *Sphaerocionium obtusum* (H. & A.) Copel.
Jambosa jambos = *Eugenia jambos* L.
Kadua = *Hedyotis*
Lagenophora mauiensis = *Keysseria maviensis* (Mann) Cabrera
Leucaena glauca = *L. latisiliqua* (L.) Gillis
Lipochaeta calycosa = *L. lobata* var. *denticulata* (Wawra) Sherff
Lucula campestris = *Luzula hawaiiensis* Buch.
Macadamia ternifolia = *M. ternifolia* var. *integrifolia* (Maiden & Betche) Maiden & Betche
Maia = *Mai'a*
Mezoneuron kavaiensis = *M. kavaiense* (Mann) Hbd.
Musa sapientum = *M. x paradisiaca* L.
Nama sandwicense = *N. sandwicensis* Gray
Panicum cinereum = *P. torridum* Gaud.
Panicum isachnoides = *P. issachnoides* Munro ex Hbd.
Panicum monticola = *P. hillebrandianum* Hitchc.

Pellaea tenuifolia = *P. ternifolia* (Cav.) Link
Peperomia reflexa = *P. tetraphylla* (Forst. f.) H. & A.
Prosopis chilensis = *P. pallida* (Humb. & Bonpl. ex Willd.) HBK.
Psidium cattleianum var. citrinum = *P. cattleianum* var. *lucidum* Deg. (probably)
Raillardia = *Dubautia*
Raillardia arborea = *Dubautia arborea* (Gray) Keck
Raillardia laxiflora = *Dubautia ciliolata* var. *laxiflora* (DC.) Keck
Raillardia menziesii = *Dubautia menziesii* (Gray) Keck
Raillardia scabra = *Dubautia scabra* (DC.) Keck
Raillardia struthioloides = *Dubautia struthioloides* (Gray) Keck
Sadleria cyatheoides (Polypodiaceae) = *S. cyatheoides* (Blechnaceae)
Scaevola frutescens = *S. taccada* (Gaertn.) Roxb.
Sporobolus capensis = *S. africanus* (Poir.) Robyns & Tournay
Stenotaphrum americanum = *S. secundatum* (Walt.) Ktze.
Straussia = *Psychotria*
Straussia kaduana = *Psychotria kaduana* (C. & S.) Fosb.
Strongylodon lucidum = *S. ruber* Vogel
Styphelia tameiameae = *S. tameiameiae* (Cham.) F. Muell.
Styphelia tameiameae of the bogs and highest Hawaiian mountain areas probably should be referred to *S. douglasii* (Gray) F. Muell. ex Skottsb., however *S. tameiameiae* does occur in certain of these areas.
Tacca pinnatifida = *T. leontopetaloides* (L.) Ktze.
Tricholaena repens = *Rhynchelytrum repens* (Willd.) C. E. Hubb
Trichomanes davallioides = *Vandenboschia davallioides* (Gaud.) Copel.
Uala = *'uala*
Ulu = *'ulu*
Viola kauaiensis = *V. kauaensis* Gray
Viola mauiensis = *V. mauiensis* Mann
Vitex trifolia var. simplicifolia = *V. ovata* Thunb.
Waltheria americana = *W. indica* var. *americana* (L.) R.Br. ex Hosaka
Wikstroemia kilaueae = *Wikstroemia* div. spec., perhaps, as there is no W. kilaueae.
Labordea = *Labordia*
Ohia = *'Ōhi'a*
Pleopeltis thunbergina = *Pleopeltis thunbergiana* Klf.

EDITORIAL

As the *Newsletter* year draws to a close, it is a great temptation for an editor, particularly a neophyte as myself, to gloat over what may be perceived as noteworthy accomplishments---the "year in review" sort of backpatting. However, I believe that this ego-inflating type of praise accomplishes little that is constructive; instead, my thoughts on some of our goals unachieved may better serve to improve our pages.

I could never emphasize enough my two strongest feelings about the *Newsletter*, namely 1) that it is our readers' publication, and 2) that it would be totally unfair to expect anyone to sacrifice the time and effort to put out an ephemeral throw-away type of sheet. Within that framework, some clarification is necessary.

The *Newsletter* is our readers' publication in the sense that it almost entirely is dependent on our readers to fill its pages; except for items as minutes of meetings, we publish little official business. In this respect, we are certainly not unique. However, there are many ways Society members and *Newsletter* readers could become more involved with our publication.

1. We are always in need of manuscripts. We have received a fair number of professional papers. Well-written student articles are especially welcome and would be mutually beneficial.
2. Contributions for our "Names and Notes" and "Calendar" are solicited --for the latter one should keep in mind the normal publication lag.
3. One of the simplest yet most useful functions this *NEWSLETTER* can perform is to record the distributional and phenological patterns of Hawaiian plants, both native and introduced. There is all too much information being carried about in people's minds---largely unavailable to most students of the Hawaiian flora---which will be lost to future workers. Until someone can be found to coordinate this effort, contributions should be sent to me, either as short notes or field guides.
4. The *NEWSLETTER* can act as a forum for the exchange of ideas, whether in the form of letters or position papers. Appropriate contributions will be used as space permits.
5. All articles are reviewed prior to their acceptance. Persons willing to help in this effort are urged to volunteer, indicating general areas of preference.

With sufficient input from our members and readers, my task will be eased considerably and the product will be one in which all can take pride. I hope that all will give these thoughts serious consideration.

MINUTES OF THE REGULAR MEETING OF OCTOBER 3, 1975

The meeting was called to order at 7:30 pm by the president, Derral Herbst. The minutes of the previous regular meeting were read and approved. The president read the Treasurer's report which indicated a balance of $855 in the checking account. There were 41 members and 18 guests in attendance.

The president asked for a motion to award (belatedly) to Layne Yoshida either a book or bond in honor of his achievement in 1974 as the senior most likely to reflect credit on botany. It was so moved, seconded and passed unanimously.

In new business, the president read part of a letter from the Future Farmers of America chapter in Pulaski County, Virginia. The chapter asked for assistance in choosing a native Hawaiian tree to be planted along with trees representing all other states in a special park in southwestern Virginia. The president asked for input from the society in answering the letter. No native trees able to withstand the climatic conditions in Virginia were known. Mr. Krisch suggested the paper mulberry tree which he knew was able to grow in Europe and which was an important plant to the Hawaiians. The secretary was asked to reply with this information.

The president announced the appointment of Jack Bell as auditor for 1975. He also announced the Nominations Committee to consist of Drs. Kefford and Sagawa and Beatrice Krauss.

Vice president Sheila Conant introduced the speaker, Dr. Charles H. Lamoureux, Professor of Botany, who gave an illustrated talk entitled, "A biological expedition to the northern Marianas."

Mr. Ted Green presented and explained several hoya plants and a vanilla orchid from John Obata was shown.

The meeting adjourned to refreshments at 8:40 p.m.

Jean Maka, Secretary

MINUTES OF THE REGULAR MEETING OF NOVEMBER 3, 1975

The meeting was called to order at 7:35 p.m. There were 52 members and 14 guests in attendance. The minutes of the previous regular meeting were read and approved as corrected. The treasurer's report indicated $774 in the checking account.

There was no new business. The vice president announced some upcoming events of interest to the Society.

Past president Dr. William Theobald made a few announcements concerning the Pacific Tropical Botanic Garden. He then introduced the speaker for the evening, Dr. R. E. Holttum, from the Royal Botanic Garden, Kew, and recipient of the Allerton Award, who spoke on tropical plants and the importance of plant taxonomy.

Ted Green displayed a magnificent hoya and Ron Hurov distributed some henna from India.

The meeting adjourned at 9:55 to the plant exchange and refreshments served by Ms. Beatrice Krauss.

Jean Maka, Secretary

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NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
C/O DEPARTMENT OF BOTANY,
UNIVERSITY OF HAWAII,
HONOLULU, HAWAII 96822

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Newsletter
Hawaiian Botanical Society

Contents

VOLUME 15 NUMBER 1 FEBRUARY 1976

RAMALINOPSIS, A UNIQUE LICHEN GENUS ENDEMIC TO HAWAII
by P. A. Bowler 4

ENDANGERED SPECIES IN HAWAII. EFFECT ON OTHER RESOURCE MANAGEMENT
by Tom K. Tagawa 7

A RESPONSE
by Charles H. Lamoureux 14

KALUAA GULCH REVISITED
by S. H. Sohmer .23

BRIEF REPORTS AND NOTES

SOCIETY BUSINESS...2, 24, 25, 27; NEW MEMBERS...3, CALENDAR...3; *Nelson* - LETTER TO THE EDITOR...6; *Krajina* - REVIEW...21; EDITORIAL...26; NAMES AND NOTES...26.

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE REGULAR MEETING OF DECEMBER 1, 1975

The meeting was called to order by the president, Derral Herbst. The minutes of the previous regular meeting were read and approved as corrected. Thirty-three members and 8 guests were in attendance.

Dr. Charles Lamoureux, on behalf of the trustees of the Marie Neal Fund, reported on minimal organizational memberships in the Friends of the Foster Garden, the Pacific Tropical Botanic Garden and the Wau Ecology Institute. He also reported that the trustees had made available $500 for the preparation of an index to the *NEWSLETTER*, Volumes 1-13.

The nominating committee proposed the following slate of candidates for Society officers for 1976: President, Dr. Gerald Carr; Vice-President, Dr. Sheila Conant; Secretary, Evangeline Funk; Treasurer, Dr. Charles Lamoureux. No nominations from the floor were made, and a motion was passed to instruct the secretary to cast a unanimous ballot for this slate of officers.

Dr. Conant introduced Derral Herbst, who gave his Presidential address.

Jean Maka, Secretary

ANNUAL REPORT OF THE SECRETARY FOR 1975

In 1975 the Society continued its tradition of presenting beautiful and/or unusual plant displays at our regular meetings. All members and guests were able to share in the two plant exchanges held this year.

A new format for the *Newsletter* was instituted and funds were approved for the indexing of all issues of the previous format.

The Society was still involved in conservation issues in Hawaii including the recurring problem of attempts to introduce axis deer to the Big Island.

The highlights of the year were the excellent botanical programs presented at each of the regular meetings:

January --- *Mr. Glen Spence* showed pictures of Lanai and spoke on the "Natural history and conservation" on that island.

February --- *Dr. Allison Kay* presented slides and a talk on "Natural landmarks in the Pacific."

March --- *Dr. F. C. Steward* gave an illustrated presentation on "Fact and fancy about cloning plants and people."

April --- *Mr. Art Whistler* showed us "People, places and plants of Samoa." In addition we were entertained by *Mike* and *Lorna McClellan* with songs about plants.

May --- At a joint meeting with the Audubon Society, *Mr. Bill Mull* presented "Some Hawaiian invertebrates: a pictorial essay and commentary."

June -- *Mr. Steven Sato* spoke on the current plant quarantine regulations of the U.S.D.A.

October --- *Dr. Charles Lamoureux* gave an illustrated talk on "a biological expedition to the northern Marianas."

November --- *Dr. R. E. Holttum* spoke on tropical plants and plant taxonomy.

December --- *Dr. Derral Herbst*, outgoing president, gave his presidential address.

Jean Maka, Secretary

Volume 14, Number 5 was mailed March 18, 1976.

ALOHA to the following new members: Gerald & Diane Carr (Department of Botany, University of Hawaii)...Elizabeth Rabakonandriania (Department of Botany, University of Hawaii)..Thecla Bennett (Department of Botany, University of Hawaii)...Ed Kramer (Department of Botany, University of Hawaii)...Jim Mowry (4025 Black Point Road, Honolulu)...Anna Mae Shishido (RR1 Box 698, Pukalani, Maui)...Marlin Huffman (General Delivery, Felda, Florida)...Diana Horton (Department of Botany, University of Alberta, Edmonton)...John & Susan Kunisaki (1701 Mikahala Way, Honolulu)...Jonathan & Adrienne Libby (312 Emeline Street, Santa Cruz, California 95060).... Dr. Garrett A. Smathers (519 Forest Avenue North, Long Beach, Mississippi 39560).

Change of address received: Sy Sohmer (Department of Botany, Museum of Natural History, Smithsonian Institution)...Erik Sandberg-Diment (RFD 1, Box 56, Hampton, Connecticut).

CALENDAR OF UPCOMING EVENTS

February

02 Bot. Soc. meeting. St. John 011. 7:30 p.m. Betsy Harrison Gagne on "Plants of New Guinea."

March

01 Bot. Soc. meeting. St. John 011. 7:30 p.m. Dr. William Theobald on "The philosophy and program of the Pacific Tropical Botanical Garden."

April

05 Bot. Soc. meeting. St. John 011. 7:30 p.m. Glen Teves, graduate student in Horticulture, on Ornamental Horticulture in Denmark. Plant donation month.

May

03 Bot. Soc. meeting. St. John 011. 7:30 p.m. Mr. Keith Woolliams (Horticulturalist, Waimea Arboretum) on the Waimea Arboretum.

RAMALINOPSIS, A UNIQUE LICHEN GENUS ENDEMIC TO HAWAII

P. A. Bowler
National Museums of Canada
Museum of Natural Sciences
Ottawa, Ontario, Canada

While compiling collections of Hawaiian plants during the mid-nineteenth century, H. Mann discovered a curious flattened lichen which he could not identify. He sent a collection of this fascinating plant along with samples of other Hawaiian lichens to the famous American lichenologist Edward Tuckerman. Tuckerman recognized the characters of the reproductive structures to be identical with those of the bushlike (fruticose) genus *Ramalina*, and described the unique plant as a member of that genus in Mann's *Enumeration of Hawaiian Plants* (Tuckerman, 1866). Tuckerman honored the pioneer collector by naming the species after him. This species subsequently has been placed in a separate section of *Ramalina* (Magnusson and Zahlbruckner, 1945) and finally in its own genus (Follmann and Huneck, 1968) of the family Ramalinaceae. *Ramalinopsis mannii* (Tuck.) Follm. & Hun. *in* Follm. is recognized as the only foliose (flattened or leaflike in appearance) member of a family otherwise characterized by fruticose growth forms. This remarkable species is endemic to the Hawaiian Islands and represents a significant divergence from its nearest relatives in the genus *Ramalina* (with over 100 species). *Ramalina* is well represented in Hawaii with over thirty species having been reported (Magnusson, 1955).

The original habitat and locality of *R. mannii* were described as "Trunks, Makawao, East Maui (Mann)," but the species is now known from other localities on Maui, Molokai and Kauai. *R. mannii* grows on the bark of trees. A. H. Magnusson, a Swedish lichenologist who published the first extensive treatment of Hawaiian lichens, recorded the species from breadfruit (*Artocarpus altilis*) and an *Erythrina* sp. (Magnusson, 1955). In the Iao Valley of Maui where it is abundant in certain localities, *Ramalinopsis* occurs on a wide variety of shrubs and trees including *Delonix regia*, *Plumeria*, *Bauhinia*, angel's trumpet (*Datura candida*) and candlenut (*Aleurites molluccana*). Elsewhere it has been collected from *Cordyline terminalis*. It is interesting that all of these substrates, with the possible exception of *Erythrina*, are introduced rather than native trees. The collection on *Erythrina* was made in 1895 by Heller, and it seems probable that the substrate species was the endemic coral tree, *E. sandwicensis*. *E. sandwicensis* occurs in dry rocky habitats up to ca. 60 meters in altitude on the lee sides of the Hawaiian Islands (with respect to the trade winds). *R. mannii* has been collected well above this elevation. However, many of the sites are in relatively mesic valleys rather than xeric slopes. All of the substrate species are more-or-less smooth barked, and the lack of substrate specificity could explain its current success of introduced smooth barked trees.

Lichens are loosely grouped into foliose, fruticose, or crustose growth forms. Crustose lichens are usually considered the most primitive growth form, and fruticose and most highly evolved. There has been convergent evolution from crustose to fruticose growth forms in unrelated lichen groups. It seems probable that *Ramalinopsis* represents a case of a foliose lichen evolving from a fruticose ancestral line, rather than the opposite which is usually considered the case. It seems likely that this genus evolved from a broad-lobed, perhaps adnate, *Ramalina* with apothecia arising from the terminal region of the ascending lobe tips. The adoption of a *Parmelia*-like growth form, melanization of the lower cortex, and the appearance of primitive rhizines were likely late events in the evolution of this species. No obvious ancestor has survived in Hawaii, and the separation from Ramalinoid lines was probably an ancient event.

This species grows in adnate, circular colonies of up to 14 cm in width, and has a shiny light greenish upper cortex. The surface is often dotted with minute, slightly raised, white dots (pseudocyphellae). The margins of the lobes tend to be upturned, and squamule-like branchlets proliferate from the margins and upper surface. The lower surface is black and shiny, becoming tan then bone white at the external margins. The lichen is attached to its substrate by simple, unbranched, black rhizines. The inner tissue of the fungal component (the medulla) is white. Apothecia are usually present and abundant, arising from the margins or the marginal area of the upper surface. Often the apothecia adorn upturned margins or are on small pedestals, giving them the appearance of being stalked. The discs are a light yellowish to greenish-white, ranging from cupped, to flattened, to crinkled and lobed, and are up to ca. 6 mm in diameter. The margin is thalline. The spores are two-celled (as in the genus *Ramalina*), eight per ascus, and usually 15-17 x 5-8 µm. Follmann and Huneck (1970) reported on the occurrence of the meta-depside homosekikaic acid, otherwise rare in the Ramalinaceae, in *R. mannii*.

This species superficially resembles a yellow-greenish species of *Parmelia* due to its foliose growth form and color. The best way for beginners to distinguish *Ramalinopsis* from superficially similar lichens is by comparing the apothecia with those of the genus *Ramalina*, and by examining the spores to make certain that they are two-celled, not one-celled as in most members of the family Parmeliaceae. Representative specimens are available for examination at the University of Hawaii lichen herbarium, in care of Dr. C. W. Smith. A more technical description of the species can be found in Magnusson and Zahlbruckner (1945, p. 4-5). A discussion of the evolutionary relationship of this species to the rest of the family is in preparation by the author.

ACKNOWLEDGEMENTS

I gratefully thank the Pacific Tropical Botanical Garden for financial support of the collection foray during which the field work for this study was accomplished. C. W. Smith and I. M. Brodo made useful suggestions during the preparation of the manuscript.

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LETTER TO THE EDITOR

1264 Aloha Oe Drive
Kailua, Hawaii 96734

December 29, 1975

Dear Sir:

By inuendo, omission, or direct statements, intentional or otherwise, *NEWSLETTER* articles too often slight or misrepresent the major conservation agency in Hawaii. A most recent example is in the October 1975 *NEWSLETTER*, in the article by Woolliams. Under "Reasons For The Present Situation" he states: "While it is true that State and National parks are providing valuable protection to many areas, the majority of the remaining Hawaiian flora is under considerable stress ----." The fact is that State parks are getting no protection. Furthermore, the State Division of Forestry is providing more intensive protection and to a much greater acreage of native flora than is the National Park System.

Woolliams implies that, except for "political and economic pressures," the forces of stress can be controlled. This is oversimplified. Even with dictatorial powers, and unlimited funds, the momentum of change cannot be stopped: the impact of 4000+ exotic plant species; new insects and diseases; exotic animals; and man's activities. The fact is that the seeds of rapid change have already been irreversibly sown. Recognizing this is the first key to preserving examples and samples of flora and ecosystems. There is no getting round this: preservation programs must be biologically attainable, as well as politically and economically attainable.

Robert E. Nelson
Member, Hawaiian Botanical Society

Ed. Note: Mr. Keith Woolliams has declined to respond, but has indicated a "hope that readers might turn again to my article and re-read it, then judge for themselves."

Ed. Note. A recent speech by Mr. Tom Tagawa has stirred considerable reaction in many quarters and has prompted several articles in local newspapers. What Mr. Tagawa thinks or does is of considerable importance to all of us. The full text which follows can serve as a useful document as it summarizes his position in his own words. The response to this speech by Dr. C. H. Lamoureux (Botany Department, University of Hawaii - Manoa) which was sent to a number of interested individuals follows.

ENDANGERED SPECIES IN HAWAII

EFFECT ON OTHER RESOURCE MANAGEMENT[1]

Tom K. Tagawa
State Forester
Department of Land and Natural Resources

I appreciate this opportunity to be here with you and with this distinguished panel at your 30th National Association of Conservation District annual convention. At this time, may I express my "aloha" to the members and participants who are here to continue their support to further enhance our nation's natural resources.

I feel rather sure that in the course of your deliberations you will be giving considerable attention to the now widespread public concern for protection of the environment and endangered species. Doubtless, the details will differ greatly from state to state, depending on the natural resources and problems of each. Yet, in principal, this critical attitude seems to be much the same everywhere. Like you, we have sometimes smarted from what we felt to be unfair accusations. More segments of the public want to be heard than ever before. Gone are the days when decisions could be based solely on the resource manager's knowledge and expertise as to what is the best resource use for the people they serve. Therefore, we must consider their views in our deliberation and decision making. And, more importantly, we must have them understand us and our programs.

Because all of us here today will be facing many critical environmental issues involving the Endangered Species Act of 1973, Public Law 93-205, "To provide for the conservation of endangered and threatened species of fish, wildlife and plants, and for other purposes," the administration of this act by the Department of Interior, U.S. Fish and Wildlife Service, will invariably have a major impact on land use and land management activities on both public and private lands in Hawaii and the nation, in view of the endangered and threatened status of many unique plants and animal species. The State Division of Forestry is very concerned with the administration of the act because the entire forest or portion of agriculture land may be locked up as a "critical habitat" or "range" for the sole purpose of not conservation, but preservation of the endangered and threatened flora and fauna. Webster's Seventh New Collegiate Dictionary defines,

---

[1] Text of an address presented at the 30th Annual Convention of the National Association of Conservation Districts (NACD), Public Lands Discussion Forum, held at the Hilton Hawaiian Village Hotel, Honolulu, February 2-3, 1976.

Conservation: As planned management of a natural resource to prevent exploitation, destruction or neglect.

Preservation: As emphasizes keeping something that is valuable exactly as it is without change.

The preservation concept will essentially negate the multiple use management program on state and private lands in Hawaii and the nation.

Today, we in Hawaii find that we cannot allocate nearly as much of our resources to a predominate single use function as we could in the past. Diverse interests are competing for larger allocation of a relatively dwindling resource base for their peculiar "needs". Resource allocation for one purpose is often at the expense of other important purposes. Various groups that are interested in our forest lands and the resources they contain have vastly different desires and needs. Naturally, each special interest group will view and judge our management decisions only in terms of their own values.

However, the Department of Land and Natural Resources has the task of managing resources in a manner that is responsive to all public needs. In our management planning, we have to avoid one-function-at-a-time thinking. Our decisions must be based on optimizing the use of the multiplicity of resources in our forest land.

Irony is that, our liberal government, with its vast resource and technical knowhow, even to the extent of sending a spaceship and man to the moon, cannot cope with this environmental problem. Environmental progress is moving much too slowly in the area of environmental enhancement, because of ambiguous enacted environmental laws.

Rene Jules Dubos, in an article, "Uneasy overlords must learn to collaborate with nature," in the Spring 1970 issue of The Catalyst, has stated, I quote, "If the ecological view of man's relation to his environment really implied a 'steady-state ecosystem', it would indeed be disheartening because it would mean the end of the human adventure. But, this need not and cannot be so. The physical structure and forces of the environment are forever changing, slowly but inexorably. Furthermore, all forms of life are continuously evolving and thereby making their own contribution to environmental changes. Finally, it seems to be part of man's nature to search endlessly for new environments, or at least for new adventures. There is no chance, therefore, of maintaining a status quo.

"Even if there were enough learning and wisdom to achieve at any given time a harmonious state of ecological equilibrium between mankind and the other components of the spaceship earth, it would be a dynamic equilibrium. Such a dynamic system would be entirely compatible with man's continuing development. *The only question is whether his development will be the outcome of blind forces engendered in a fight to the death between man and nature, or whether man can guide it by deliberate, rational choices."*

The Catalyst magazine sums up the article "Uneasy overlord must learn to collaborate with nature," that, "it means not just conserving nature as it is. Many key elements of our environment are past conserving. They are so polluted that the quality must be restored or newly created. Also, keeping things as they are is impossible. There is nothing static about life process; it involves constant change and we must change to meet shifting needs and aspiration."

To better understand the socio-economic impact from the extinct, endangered and threatened fauna and flora in Hawaii, can you imagine Hawaii without sugar cane, pineapple, macadamia nut, papaya and the exotic flowers?

Because of these industries, Hawaii is among the leaders in tropical agriculture in the nation and the world. If Hawaii is to retain the present standards of living and remain viable, we must further develop our growth potential in the area of diversified agriculture. Therefore, we must be permitted to modify and develop our native forest. We must be allowed a parallel program of economic development and preservation of our ecosystem. Otherwise, Hawaii will be stagnated and alternatives must be made to lower our standards of living to which we are not accustomed to.

The Hawaiian Islands, by nature of its own origin, evolved apart from large continents by volcanic actions in the middle of the Pacific Ocean and are thus isolated from other large land masses. This isolation has created an unique biological system on the islands where plant and animal life have evolved and radiated into many endemic species, that is, they are native only to Hawaii. It has been estimated that 2,000 native species of fauna and flora in Hawaii are rare and in danger of extinction. While most of the these endangered organisms are insects and mollusks, about 640 species are native plants, and 19 species of endemic forest birds are listed as endangered. In Hawaii, preservation of natural ecosystems has been aided by the system of forest reserves, established in in the early years of this century to protect the watersheds. Fence construction and elimination of domestic and feral animals, control of fires and simply closing of these areas to unregulated exploitation have contributed greatly to the preservation of Hawaii's indigenous plants and their associated fauna. Nevertheless, aggressive introduced plants, insect pests, birds, animals and forest disease appear to be here to stay and some continue to spread. Most of our forest reserves are not in a wholly pristine condition. For example, *Clidemia hirta,* a perenial plant pest is rapidly spreading throughout our Koolau Mountains on this island. *Passiflora mollissima,* an exotic passion fruit species, has escaped into prime native koa forests on the Big Island and Kauai. Moreover, in some of our more or less pristine forests, native tree species are deteriorating rapidly. To make this situation worse, these forests are not regenerating in the face of competition by invading exotic plants, insects and disease. To illustrate, 200,000 acres of our native ohia forest are deteriorating from ohia decline on the island of Hawaii. This is also the habitat for many endangered fauna and flora. However, extensive research is currently being conducted to determine the cause and possible control of the decline.

I am sure, those of you who are here today are aware that plants, insects, snails, mammals and birds do not live independently of each other, but intimately associated and live together to their mutual advantage. I am sure, those of you who are here today are also aware that manipulation of the forest environment, through such practices as timber harvesting, site preparation for planting of trees, noxious weed control, and trail or road construction, may have a profound effect on the environment of the native animal life and particularly the bird habitat, especially in respect to their food and cover.

A major objective of wildlife research which is yet to be achieved in Hawaii is the determination of the biology, ecology and population dynamics of our native bird species in their forest habitat. Foresters need to know both the beneficial and detrimental effects on birds and other animals that may result from timber stand improvement, timber harvesting and other protective and management activities. This information is vital for the foresters to make future forest management decisions to conserve our native birds and our endangered species as a whole. To obtain a better understanding of the life history for the various rare and endangered species of birds and other animals, we need to accelerate research to get facts on the following:

1. the population numbers.
2. the present distribution.
3. both general habitat and more importantly the critical factors of habitat, both positive and negative.
4. the food habits and requirements.
5. use of exotic insects and plants for food.
6. migration patterns.
7. the nesting site requirements.
8. breeding data.

The current study program is not adequate considering the magnitude of the present problem of maintaining all endemic species. To date, there is hardly any data relative to the above-mentioned items, except fragmentary and scattered reports. Therefore, we need complete ecological information factually presented. Then, we can relate these facts to the demand upon our forest resources. We must recognize that powerful forces are at work. Some such as fire, we can control, more or less. Others such as introduced pests, urban sprawl, farming, lava flows and industrial development are even harder to resist.

Certain scientific and preservationist communities in Hawaii and the nation constantly accuse the State Division of Forestry's reforestation practices as the main cause of the extinction of native birds. They have minimized or played down critical factors of the decline or extinction of native birds due to, (1) avian disease, (2) competition with exotic birds,

(3) feather collecting, (4) predation, (5) even lava flows, (6) forest fire, and (7) forest clearing for agriculture, grazing and other uses. These factors played a tremendous role in the extinction of our native fauna and flora. It is recorded that no land birds are known to have become extinct since 1935; most of it occurred before the turn of the century. In recent years, numbers of supposedly extinct organisms, including birds and plants have been found. Further, a few years ago, a new species of native bird was discovered on the island of Maui.

Our most recent escapade with the Endangered Species Act of 1973 was the publication titled, "Report on endangered and threatened plant species of the United States" prepared by the Smithsonian Institution, as directed by the U.S. Congress. This report indicated that Hawaii's indigenous flora consisted of over 2,200 species, subspecies and varieties, and 1,088 of these species are listed as extinct, endangered or threatened.

We recognize at this time, it is impossible to fully assess the potential implication of the Endangered Species Act of 1973 because the "critical habitat" for the endangered species has not been established.

Section 7 of this Act, dealing with intergovernment cooperation and critical habitat, is the sleeping giant--when this giant wakes up...wow! He and the environmentalists will roar and shake-up all the land managers. Therefore, while the giant is still asleep, we should request the U.S. Fish and Wildlife to develop criteria or standards on how the "critical habitat" will be determined as to their geographic size. We should not be complacent with our demands. We must be sure that the constraints of the "critical habitat" are clearly spelled out in black and white before they process the final rule making in the Federal Register.

In April of last year, I asked the Smithsonian Institution for data that they have available as to how the listing was selected and whether they have a base map delineating the locations of the 1,088 Hawaiian flora listed as extinct, endangered or threatened. Instead of receiving a response as to data available and base map showing the location of critical or threatened plant species, they camouflaged the issue by accusing the Division of Forestry activities caused much of the endangerment of native fauna and flora in Hawaii, which is not true as stated earlier.

We believe the power of the Endangered Species Act places a tremendous responsibility on those compiling the endangered species list. Care and selectivity must be used when nominating species because of the major impact and restriction the endangered plants and their habitat will have on such activities as pasture improvements, forestation, game management, conversion of forest lands for other agricultural use and even forest recreation.

I am highly concerned because the intelligent selection of endangered and threatened species and their critical habitat must be based on factual data, not on the basis of emotions. To date, no data was supplied to us indicating populations, locations or ranges of the plant species listed as endangered or threatened. Because the list includes species which are obviously not endangered, I doubt that the list is the result of an orderly field survey for endangered and threatened species throughout the State.

This, of course, raises the possibility of barring species listed merely because they have not yet been found in abundance due to inadequate exploration.

Very little other than basic taxonomic work has been conducted for much of Hawaii's native flora. In many cases, the present taxonomic classifications are based on the phenotype rather than the genotype. There is, even among expert local taxonomists, disagreement as to the interpretation of certain subjective taxonomic descriptions, particularly at the infraspecific levels. In many instances, such listing at the varietal level are of no value to implementation of the Endangered Species Act.

There are excessive instances in the list where species are categorized to the varietal level. In view of the taxonomic uncertainties, this is much too fine a breakdown. Moreover, listing plants at the varietal level is not necessary to protect the species nor is it required by the Endangered Species Act (Section 3(11)). The proposed endangered species list included inconsistencies where species were listed as extinct while varieties of that species were considered endangered or threatened. Obviously, if a variety of a species exists, the species exists.

In several instances, only the genus was listed such as, *Artemisia* sp. and *Gouldia* sp. Listing at the generic level does not relate to any one particular species and is too broad to be a meaningful inclusion in the endangered and threatened species list. These are some of the examples leading us to believe that the Hawaii plant list in the July 1, 1975 Federal Register must be revised.

The Hawaiian endangered and threatened plant species list, with all its implications, is too important to be cluttered with non-valid listings. We cannot afford to dilute our protective efforts by directing attention to species which are not endangered or threatened. In view of the restrictive management practices that may result from the creation of critical habitats for these species, we must insure that the list is accurate and based on factual data. This is especially true in Hawaii where the limited land must be utilized to the utmost to fulfill the needs and aspiration of its people.

The most dishearting thing that we here today should be concerned with is the manner in which the Smithsonian Institution and the U.S. Fish and Wildlife Service are going about establishing the endangered and threatened plant list. Our concern should be focused on the sleeping giant, the "critical habitat." How will the critical habitat or range for the endangered fauna and flora be determined. I have been advised at the Endangered Plant Symposium which was held in New Mexico in December 1975 that the Smithsonian Institute personnel indicated that there are *no plans to release any of the supporting data as to why a plant is listed as endangered or threatened to anyone*. Withholding this data makes me doubt the creditability of the Smithsonian Institution's Endangered Plant List published in the Federal Register. I see no reason for the Smithsonian Institute and the U.S. Fish and Wildlife Service to withhold this data unless there is something to conceal.

Further, it was reported that there will be very little change in the proposed list of endangered plants, as compared to the preliminary list. The reason being that supporting data must be provided for each plant to be removed from or added to the list. Why should the states be required, post facto, to provide supporting data to remove a plant species from the list. The burden of proof should not lie with the states but with those who initially compiled the list. Insofar as I am concerned, their position is capricious and arbitrary. How can we develop a sense of trust and amicable working relationship on such a sensitive program as the endangered species with this kind of attitude.

Since the protection of the "critical habitat" where the endangered species exist is so important, I would like to pose a very pertinent question regarding this matter of protection. Will the Federal Government provide additional funding for forest fire protection, in view of our many endangered and threatened flora and fauna? The devastating effects of a forest fire can result in the extinction of many endangered or threatened species within a very short period. Therefore, without an adequate fire protection program, there is little sense in creating a "critical habitat." This protection is not only limited to forest fires but also for forest pests such as insects, diseases and weeds whose damage to the forest are great, but not as pronounced as forest fires.

I must reiterate that the implications resulting from the creation of an endangered plant list and the delineation of critical habitats for these species will have a major impact on land management practices. This impact will be greater in Hawaii because of our limited land area. Therefore, it is my firm belief that before the U.S. Fish and Wildlife Service publishes the final endangered and threatened plant list and the critical habitat or range in the Federal Register, they should be required to do the following:

1. Insure that all data indicating that a species is endangered or threatened is made available to the public.
2. Indicate the extent of the survey conducted within each state for each endangered or threatened species and the methods used.
3. Delineate on base maps the locations of each endangered and threatened species.
4. Develop the criteria or standards for critical habitats and geographic areas for threatened and endangered species. A very important factor here is the knowledge of the biology and ecology for each endangered and threatened species.
5. Provide an opportunity for full participation to all public and private landowners which are liable to be affected.
6. Information about the program should be more readily available to the landowners so that they understand the benefits and how he may be affected by the program.
7. Finally, a public hearing should be held in each respective state before any final rule making for endangered and threatened species is processed in the Federal Register.

In closing, I wish to quote a passage from our former Governor John

A. Burns in his State of the State Address in January 1970, which he eloquently summarizes, in my opinion, the Endangered Species Act of 1973 in a few sentences.

> "It should be remembered that the key ingredient in any environment is man himself. He is part, and parcel of and the key to the value of our total system of symbiotic relationships on this earth.
>
> Being a part of the environment, our system demands that we consider human economics together with biological ecology.
>
> If man is hungry, ill-housed, under-educated or poorly treated in his society, what service is it to him that his environment remains in its pristine, natural state?"

Dr. Lamoureux's response:

February 5, 1976

Dear Tom:

Although my university responsibilities prevented my attendance at your February 2nd talk to the National Association of Conservation Districts Convention, I have read your speech with great interest. I had hoped to find in it some clear policy statements as to how the State of Hawaii was planning to implement the provisions of endangered species legislation. Unfortunately, I was disappointed, as the speech seems to me to be primarily an attack on the legislation itself, and your concerns about the problems it will create for land managers.

As one who has long been concerned with the recognition and protection of rare and endangered species, I feel I must do something to assist in the effective implementation of the legislation. As one who believes that education is primarily a search for truth, it seems to me that perhaps some mutual education would be useful in helping to resolve existing conflicts, and bring about earlier and more effective protection of rare and endangered species. It is in this spirit that I offer my comments.

While there are considerable differences of opinion on this complex subject, these differences of opinion are useful if they are based on differing interpretations of the same set of facts. When such differences are based on different facts, it would seem to be a necessary first step to establish a factual basis for our discussions. My comments are keyed to references in the distributed copies of your February 2 talk, but they apply equally to similar comments made in various documents, including:

July 30, 1975 memo from Robert E. Nelson to Paul C. Guilkey
August 22, 1975 letter from Governor George R. Ariyoshi to F. Eugene Hester

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WILLIAM J. HOE

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ARTICLES AND NOTES

Page
Autecological Review of *Sophora chrysophylla* in Hawaii (T. Parman).. 40
BRIDGES, K. W.: Seagrass Ecosystem Study.............................. 31
Calendars.. 19, 35, 53, 90
Collecting Mushrooms for Identification (C. Smith).................. 84
CONANT, S.: Hawaii IBP Project.. 3
    Testimony.. 81
Conservation Columns (R. Gay).............................. 11, 25, 69
CRAINE, C.: Dangerous and Endangered Species: A Political
    Update on Native Ecosystems.......................... 13
Dangerous and Endangered Species: A Political Update on
    Native Ecosystems (C. Craine).................................. 13
DEGENER, O. and I. Degener. (Review of Schultze-Motel)............. 78
Editorials... 18, 121
GAY, R.: Conservation Columns.............................. 11, 25, 69
Hawaii IBP Project (S. Conant)... 3
HERBST, D. R.: (Review of Sutton)...................................... 32
HOE, W. J.: Observations on *Fissidens crumii* (Bryopsida:
    Fissidentaceae), An Endemic Hawaiian Species......... 51
ISHIKAWA, S.: Lyon Arboretum Association............................. 80
KNAPP, R.: Vegetation of the Hawaiian Islands (Translation)........ 95
LAMOUREUX, C.: Recent Pacific Publications......................... 26, 69
    Harold St. John-Awards.............................. 82
    Thirteenth Pacific Science Congress................. 85
LIETH, H. et al.: *Portulaca pilosa* ssp. *villosa*; Ecotype
    of *P. pilosa* of Great Variability and
    Adaptibility.................................. 23
Lyon Arboretum Association (S. Ishikawa)............................. 80
Lyon Arboretum Notes (K. Nagata)................................... 50, 80
NAGATA, K.: Lyon Arboretum Notes................................... 50, 80
Names and Notes.. 33, 53, 90
New Members.. 19, 22
Observations on *Fissidens crumii* (Bryopsida: Fissidentaceae),
    An Endemic Hawaiian Species (W. Hoe)........................... 51
Officers.. 38
PARMAN, T.: An Autecological Review of *Sophora chrysophylla* in
    Hawaii.. 40
Portulaca pilosa ssp. *villosa*; Ecotype of *P. pilosa* of Great
    Variability and Adaptibility (H. Lieth et al.)................. 23
Propagation of Hawaiian Endangered Species (K. Woolliams)........... 59
Recent Pacific Publications (C. Lamoureux)......................... 26, 69
RUSSELL, D.: Dr. George Russell...................................... 52
Russell, George (D. Russell)... 52
Schultze-Motel, W. (Review by O. & I. Degener)...................... 78
Seagrass Ecosystem Study (K. Bridges)................................ 31
SMITH, C.: Collecting Mushrooms for Identification................. 84
Society Business.................................... 2, 22, 39, 53, 58, 122
St. John, H.-Awards (C. Lamoureux).................................. 82
Sutton, S. B. (Review by D. Herbst).................................. 32
Testimony (S. Conant)... 81

Page
Thanks.. 55
Thirteenth Pacific Science Congress (C. Lamoureux)................. 85
UH Research Activities.. 55
Vegetation of the Hawaiian Islands (R. Knapp; translated by
A. Yoshinaga and H. Iltis)...................................... 95
WOOLLIAMS, K.: Propagation of Hawaiian Endangered Species.......... 59
YOSHINAGA, A. and H. Iltis: Vegetation of the Hawaiian Islands
(Translation of R. Knapp)....................................... 95

CORRIGENDA

page, line	for	read
3, 3	Research,	Researcher,
3, 16	throughtout	throughout
16, 23	asix	axis
18, 7	consid ring	considering
18, 12	statemetn	statement
18, 41	Unitl	Until
21, 5	Leith, Leith, Leith	Lieth, Lieth, Lieth
23, 3	Leith	Lieth
31, 38	tranches	trenches
32, 16	Rock	Joseph Rock
45, 35	inclusive	inconclusive
123, 8	Krisch	Kirsch

REVIEWERS OF ARTICLES

appearing in Volume 14 (1975)

Bridges, K. W.
Herbst, D. R.
Lamoureux, C. H.
Mueller-Dombois, D.
Smith, C. W.

I particularly wish to thank Dr. Charles Lamoureux, Ms. Ruth Gay and Mr. Ken Nagata for their willingness to undertake the thankless, time-consuming task of authoring regular columns. Dr. C. W. Smith contributed the unsigned article on p. 55.

W. J. Hoe
Editor

December 1975 article by Tom K. Tagawa, "Endangered Plants," Honolulu Star-Bulletin

A. Conservation vs. preservation (pp. 8-11). I suspect that no serious student of Hawaiian biology would opt for strict preservation of endangered species. For one thing, it's illegal. Public Law 93-205, The Endangered Species Act, in several places (such as Sect. 6, (a), (b), (c)) speaks to conservation of endangered species. Sect. 3 (2) states "The terms "conserve," "conserving," and "conservation" mean to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary. Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as ..." Thus the law would seem to mandate conservation (per your definition on p. 8, "planned management of a natural resource to prevent exploitation, destruction or neglect.") not preservation (per your definition on p. 8, "keeping something that is valuable exactly as it is without change.")

Furthermore, any serious student of Hawaiian biology or natural resource management should be aware that strict preservation methods just don't work. Building a fence around a Hawaiian forest, and enforcing a total Kapu will ensure the destruction of that bit of forest. Management, such as control of feral and game mammals and weedy plants, is essential if conservation is to be achieved. We all want to follow the law by managing the population of an endangered or threatened species to the point where it is no longer endangered or threatened. This is conservation, not preservation. To this end, I suspect any serious student of Hawaiian biology would agree with the statement by Dubos which you quoted on pp. 8-9. The problem is that I would probably interpret "*The only question is whether his development will be the outcome of blind forces engendered in a fight to the death between man and nature, or whether man can guide it by deliberate rational choices*" differently from you. I would look upon conversion of a block of prime native forest to a eucalyptus plantation as an example of "a fight to the death between man and nature," and the retention of the area in native forest as "a deliberate rational choice." You might place different interpretations on such actions.

B. Protection of endangered species is a single use function (p. 8). Does this mean that once an acre is set aside for endangered species protection the rain will cease to fall there, or fail to run off or percolate the soil there, or that the watershed potential is in any way diminished? Of course not.

Endangered species protection is as compatible with the multiple use concept as are most other forest uses. The 1975 document "A Program for the State Forest Lands of Hawaii" lists six forest resources in Hawaii, water, timber, recreation habitat, wildlife habitat, forage, flora and fauna preservation (your word, not mine). The following table shows what I believe to be a summary of compatible uses of state forest lands:

	Primary Uses					
Associated Uses	Water	Timber	Recreation	Wildlife	Forage	Flora/ Fauna
Water		±	±	±	-	+
Timber	±		±	±	-	-
Recreation	±	±		+	-	±
Wildlife	±	±	±		-	±
Forage	-	-	-	-		-
Flora/Fauna	+	-	±	±	-	

+	compatible use
±	compatible use under some circumstances
-	incompatible use

In my opinion this table suggests that protection of endangered species fits into a multiple-use approach to land management just as well as most other uses do, and is much more in keeping with the multiple use concept than the forage use is.

C. Accusations (p. 10). You state "Certain scientific and preservationist communities in Hawaii and the nation constantly accuse the State Division of Forestry's reforestation practices as the main cause of the extinction of native birds." In my opinion this is wholly inaccurate. No scientific group worthy of the name would make such a statement, for several reasons. 1. There is no record of extinction of any native bird species since statehood. Before statehood there was no State Division of Forestry. 2. Any scientist who has studied the situation recognizes that the causes of native bird extinction are varied and complex. There is no "main cause" generally agreed upon by those familiar with the facts. 3. No one contends that reforestation of non-forested areas is a cause of extinction. The argument is that deforestation of currently forested areas, and the replacement of native forests by exotic forests could well become a cause of extinction of native birds in the future. This is a very different statement from the one you made.

D. The "Smithsonian List" - a brief history. In various documents you and other officials have criticized the list of proposed endangered and threatened species which was published in the Federal Register of July 1, 1975. Among other things criticism has been directed at the brief length of time devoted to preparation of the list, and the fact that the list in the Federal Register contained inadequate information. The latter criticism is certainly justified (although a perusal of the documents which preceded the Federal Register listing would have clarified things considerably). The former seems to me unjustified, and the following chronology is an attempt to document its history:

1. 1932 - F. R. Fosberg arrived in Hawaii and began his studies of Hawaiian plants, which are still continuing.
2. 1953 - Pacific Science Association Standing Committee on Pacific Botany initiated a project to produce a documented list of rare and endangered plants of the Pacific Basin. Dr. Fosberg has been the prime mover of this project since its inception.
3. 1961 - 10th Pacific Science Congress in Honolulu. Data cards soliciting information on rare and vanishing plants in the Pacific Basin were distributed to interested people, and over the next decade, on periodic prodding from Fosberg, were submitted to him.
4. Early 1970 - In preparation for the forthcoming Smithsonian conference, data cards were again distributed to many knowledgeable people in Hawaii, including botanists and foresters. (I don't know who was on the distribution list, but I do know we had replies from L. W. Bryan and Norman Carlson).
5. May 1970 - Smithsonian Institution and Pacific Tropical Botanical Garden co-sponsored a 3-day symposium on endangered species in Hawaii. At that time a preliminary list of endangered plants, prepared by Fosberg from the information submitted to him by all informants, was circulated for discussion. Copies of this list were widely distributed for additional comment in Hawaii.
6. December 1970 - Second symposium on endangered species in Hawaii held in Honolulu, co-sponsored by Smithsonian Institution, Pacific Tropical Botanical Garden, and the Western Society of Naturalists. Among speakers in this symposium were Ralph Daehler and Russell K. LeBarron of the State Division of Forestry.
7. 1970-73 - Various revisions were made in the proposed list of endangered plants by Herbst and by Fosberg as more information accumulated.
8. 1973 - Harold St. John's "List and summary of the flowering plants in the Hawaiian Islands" was published, offering for the first time since 1888 an essentially complete list of Hawaiian native plants.
9. Fall 1973 - Armed with the St. John book and various proposed lists of endangered plants, Derral Herbst, Betsy and Wayne Gagne, Steven Montgomery, John Obata, and Charles Lamoureux met on several occasions to compile observations and make recommendations for inclusion in the list. These people represented the scientists who had conducted the most extensive botanical field work in Hawaii in the recent past, and who would be expected to have reasonably accurate knowledge of plant distribution. While no members of the State Division of Forestry were active participants in this group, each of the members of the group has had assistance from foresters in locating rare species and some of the members frequently received specimens for identification which have been collected by Forestry personnel. In my opinion, the deliberations of this group formed a major source of information used in preparation of the *Allertonia* list. Fosberg and Herbst then completed the list, exercising final judgment as to what should be included.

10. December 28, 1973 - Endangered Species Act of 1973 was enacted.
11. 1974 - Two things were occurring simultaneously.
    a) The Fosberg and Herbst list was submitted to the Pacific Tropical Botanical Garden for publication in its new journal *Allertonia*. As this list was finally published it contained an introduction which carefully indicated the preliminary nature of the list, and which defined the categories (rare, local, depleted, endangered, etc.) used in the list.
    b) The Secretary of the Smithsonian Institution, in accordance with the Endangered Species Act of 1973, was compiling the list of endangered and threatened plant species of the United States. Since Dr. Fosberg is a senior staff member at the Smithsonian he was involved in modifying the Fosberg and Herbst list to fit the requirements of the Act. For example, the Fosberg-Herbst list did not include the category "threatened" but did include "rare," "local," "depleted," etc. It also includes a number of plants of uncertain status. The plants of "uncertain" status, plus some others ("increasing," "stable," etc.) were removed from consideration, the remainder were reclassified as either extinct, endangered, or threatened. It is of interest to note that the Fosberg-Herbst list contained entries for 1765 taxa, while the Smithsonian list included only 1088 taxa of Hawaiian plants.
12. December 15, 1974 - Report on Endangered and Threatened Plant Species of the United States was presented to Congress by the Secretary of the Smithsonian Institution. It was printed early in 1975 as House Document No. 94-51.
13. March 1975 - The Fosberg-Herbst paper "Rare and Endangered Species of Hawaiian Vascular Plants" was published in *Allertonia* 1: 1-72.
14. July 1, 1975 - Publication of the "Smithsonian List" in the Federal Register.
15. August 22, 1975 - In letter from Governor Ariyoshi to F. Eugene Hester the State of Hawaii presented its "Edited List." This list does not name the individuals involved in its preparation, but does state in a general way the criteria which were used.

This chronology suggests to me that the "Smithsonian List" was not a document which was hastily thrown together. It has had a gestation period of over 20 years. The fact that it is not wholly complete or totally accurate should not be considered as criticism to negate its positive value. I believe it and the Fosberg-Herbst list to be the best working documents available at the present time, and these are the lists on which we can and should build our knowledge of endangered Hawaiian plants. The shortcomings of the Fosberg-Herbst list are documented by the authors in the *Allertonia* paper; those of the Smithsonian List in House Document 94-51.

E. No data have been supplied indicating populations, locations, ranges (p. 11 of your paper) or descriptions (Nelson's memo) of the taxa listed. The list in the Federal Register, and list in the Smithsonian Report are both very brief, and such data are not given there. However, the Hawaiian plants all appear in the Fosberg-Herbst list in *Allertonia*. That list, as explained in its preface, follows St. John's 1973 checklist. In the St. John checklist are given both the distribution by island and a reference to the place the name was published. Checking these references would give one both a detailed description of the taxon and a discussion of the range of the plant.

In the Smithsonian list Hawaii has not been treated any differently in this respect than the other 49 states. We are fortunate in having the St. John checklist to aid us to find the essential information quickly.

F. Hawaiian plant taxonomy is in such a state of confusion as to be of little value in preparing a list (p. 12). All are agreed that taxonomy is at best an imperfect art, and that we will never have complete agreement on any taxonomic system. However, we must work with what we have - and reference to the appropriate publications is essential to our understanding of what another person means in using a particular name. In this case references to publications are available in St. John.

G. Use of varieties in the list is inappropriate (p. 12). This depends on the interpretation of the law. P.L. 93-205, Sec. 3 (11) says "The term 'species' includes any subspecies of fish or wildlife or plants and any other group of fish or wildlife of the same species or smaller taxa in common spatial arrangement that interbreed when mature." Perhaps the law should be amended by adding "or plants" after the second "wildlife." However, I think that other provisions of the law still enable protection of varieties.

1. Sect. 3 (4) defines "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range" and Sect. 3 (14) defines "threatened species" in a similar manner. Since the term "variety" in botanical nomenclature is often used to designate those plants in one geographical area (e.g., var. *mauiensis*) which are somewhat different from those in the rest of the range of the species, then the variety would be included under the law.

2. Sect. 4 (3) (e) which deals with Similarity of Appearance cases could also be applied here.

3. I think that the omission of variety in the law was perhaps an oversight. The law was originally written for animals; plants were tacked on later. Most zoologists use the category "subspecies" for subdivisions of a species, most botanists use the category "variety" for similar subdivisions. (There are also some botanists and zoologists who use both terms, just to confuse the issue). In many cases then, the zoological subspecies and the botanical variety are approximately equivalent terms, and should be treated equally under the law.

4. Any botanist who felt so inclined could publish a paper renaming all the varieties as subspecies, at which point scientific credibility might be stretched but legal requirements would be met.

In my opinion all this indicates is that we shouldn't get hung up over whether something is a species, a subspecies, or a variety. The intent of the law seems clear from Sect. 3 (11) - "the protection of smaller taxa in common spatial arrangement that interbreed when mature". In this sense, it really doesn't matter whether the kokoolau plants on top of Diamond Head are called *Bidens cuneata* or are considered to be a hybrid between *B. mauiensis* and *B. molokaiensis*. What does matter is that there is a population of interbreeding plants different from all others in the world, and there are no more than 50 plants in this population, that one fire could wipe them out, and that we ought to be protecting them under the law rather than arguing about their taxonomy (that being an appropriate subject for the taxonomic botanists rather than the natural resource manager).

H. There are inconsistencies in the list in that some species are considered to be extinct while varieties of that species were listed as endangered or threatened (p. 12). Please give an example here - I've read through the list 3 times looking for this and I can't find any examples.

I. In several instances only the genus was listed, such as *Artemisia* sp. and *Gouldia* sp. Listing at the generic level is too broad (p. 12). I find only 3 such instances. In each case, reference to the Fosberg-Herbst list would make clear that each of these is a newly discovered species which is in the process of being described but does not yet have a formal name. However, the Fosberg-Herbst list does give enough information to indicate which plant is involved.

Asteraceae	*Artemisia* sp.	Kaiholena Gulch, Lanai	Endangered
Primulaceae	*Lysimachia* sp.	Waihoi Valley	Endangered
Rubiaceae	*Gouldia* sp.	Herbst, Mt. Kahili, Kauai	Possibly endangered (= Threatened on Smithsonian list)

J. Care and selectivity must be used when nominating species because of the major impact and restriction the endangered plants and their habitat will have on such activities as pasture improvements, forestation, game management, conversion of forest lands for other agricultural use and even forest recreation (pp. 11-13).

I must disagree with you. Care and selectivity must be used when nominating species to ascertain that the species are endangered or threatened as provided by law. Such determination should be a scientific, not a political decision. Whether a species is endangered or not is a matter of biology. What we decide to do about it is matter of politics. Therefore, let's base determinations of endangered or threatened species on scientific evidence; then we can make the necessary political decisions whether to protect them or not. I concur fully with your statement (p. 11) that "the intelligent selection of endangered and threatened species and their critical habitat must be based on factual data, not on the basis of emotions", I submit that factual data, not emotions, formed the basis of the Fosberg-Herbst list and the Smithsonian list.

K. There are no plans to release any of the supporting data as to why a plant is listed as endangered or threatened to anyone (p. 12). If this is fact, and not merely hearsay, I am as appalled as you are. I cannot believe it is true, and suspect such a policy to be contrary to the law (Sec. 4 (b); Sec. 4 (c) 2; Sec. 6 (c)). Under Sec. 6, Cooperative Agreements with the States, I would think such information would have to be released to the states. I do have one minor reservation about full release of information - while base maps showing the location of each endangered or threatened taxon should eventually be prepared, I do feel such maps should not be readily available to everyone and anyone. Based on experience in Britain and elsewhere, the surest way to wipe out a population is to publish a map showing exactly where the last of it is found. So, much as it conflicts with my principle that all knowledge should be universally accessible, I would be inclined to restrict this information on a "need to know" basis. At the moment, with no maps, there is no problem.

This points up what seems to me to be our mutual major concern: gathering more factual data on endangered species. This is the area to which we should now both be devoting our energies. I would be happy to talk story with you on this matter at your earliest convenience, to see if there is some way we could cooperate in this matter.

REVIEW

Mueller-Dombois, Dieter, and Heinz Ellenberg. 1974. *Aims and methods of vegetation ecology.* John Wiley & Sons, Inc., New York. 547 p. $13.95.

It is not easy to write a review of a book, in which the "senior" writer (Dieter Mueller-Dombois) was a student of mine during his PhD studies at the University of British Columbia: some readers might be suspicious that I am doing him a favour because of that special relationship. So, I had better be as critical as is expected from somebody asked to write a book review.

The book was evidently prepared and written mainly on the basis of references published before 1973. Thus, only six references printed in 1973 were quoted, and only one, published in 1974. If it was not printed until 1974, it becomes obvious that the printers could have done more to speed its edition. If they were slow they should apologize to the authors, because every field of science progresses rapidly in our time.

Another critical comment I wish to make concerns the paging of the book. It was done in a very unorthodox way (on the left side of each page except the last few pages dealing with the Author Index).

Having presented these "critical" comments, I am obliged to speak only in superlatives about both authors. They created something that has not been done by anybody else in a comparable form to the present time.

They dealt with different philosophical approaches in vegetation ecology in an admirably unbiased form such as should be found in all textbooks, where every scientific approach requires a sympathetic presentation. I am rather doubtfulthat this could be accomplished by somebody who is completely brainwashed for ordination methods because he usually has no understanding for any experience in nature and likes to conceal his shortcomings with mathematical ornamentations, frequently revealing very little about nature. On the other hand, those who believe strongly in vegetation or even ecosystem classification, would not be able to present all highly sophisticated ordination techniques because they frequently--rightly or wrongly--ridicule them. Nevertheless, here we have two authors, Mueller-Dombois and Ellenberg, who proved that both strongly polarized approaches could be presented side by side, and let the students decide which they wish to apply for their studies (perhaps even using both of them).

This book was based on the publication "Aufgaben und Methoden der Vegetationskunde" (1956) by Heinz Ellenberg, one of Europe's most outstanding plant ecologists, living mainly in Germany (temporarily in Switzerland also). However, this book, revised, broadened and deepened by Dieter Mueller-Dombois in close cooperation with Heinz Ellenberg is a new textbook, which will be so useful in ecological studies either at the universities or in the field that it should not be omitted by any serious student of ecology for some time.

The book is divided into five parts: general concepts; vegetation analysis in the field; classifying and ordinating vegetation data; spatial and temporal explanations of vegetation patterns, including vegetation- and site-mapping; and a synthesis of aims and methods in vegetation ecology. In the three appendices the following keys were presented by the authors: revision of Raunkiaer plant life forms; tentative physiognomic-ecological classification of plant formations of the Earth; mapping structural vegetation types in southeast Ceylon; and mapping forest habitat types in southeast Manitoba.

I do not wish to discuss every chapter of this book in any detail. It would be necessary to write another book if I were to do it adequately. I would recommend that every synecologist read this book because it will be revealing to everybody, even to those who consider themselves well experienced. It is difficult to discover any substantial shortages. Indeed, even if the book has only 547 pages whereas the 3rd edition (1964) of Braun-Blanquet's "Pflanzensoziologie" has more than 300 additional pages (865), this textbook brings a much wider and deeper outlook for vegetation studies in our time. I could perhaps be puzzled as to why the study by Ivimey-Cook, R. B. and M. C. F. Proctor (The application of association-analysis to phytosociology, Journal of Ecology, 1966) was not included, when the classification methods were presented, but this might be considered as my personal pet.

This book might force the staunch ordination method defenders to stop for a while and re-think their rigid opposition toward continental European synecology, which frequently leads them into almost maniacal behaviour. They should realize that they have fussed too much over the mathematical and statistical accuracies in vegetation aspects, where everything grows daily, and even yearly, not only above ground but also below it, and that such "accuracies" should be played with only by those who are not yet completely adult in their understanding of vegetation science. Indeed, if they had realized this much earlier, we could have many informative studies on vegetation structures and its environment in different parts of North America as well as in the tropics where virgin nature disappears quickly. We could have even more time in preserving such areas where studies had revealed more on nature, and in keeping them as our national and international heritage. I am confident that this excellent textbook, in presenting the intricacies of vegetation studies, may help substantially to settle all so-called vegetational controversies before it is too late.

Dr. V. J. Krajina
Honorary Professor
Department of Botany
The University of British Columbia
Vancouver

KALUAA GULCH REVISITED

S. H. Sohmer
Associate Professor and Director of the Herbarium
University of Wisconsin
La Crosse
(On appointment to the Smithsonian.)

It was my great delight recently to be able to return to the Hawaiian Islands on my way back to Washington from Sri Lanka. The short stay on Oahu, as well as the field work in Sri Lanka itself, was made possible by a Smithsonian Research Fellowship which has enabled me to commence a study of *Psychotria* in the Pacific. I utilized part of my time while in Hawaii to do field work and took the opportunity to return to some sites that had been important to me during the work which led to a revision of the genus *Charpentiera*. It is an aspect of this field work which has prompted me to submit this note to the *Newsletter*.

My delight at being back in Hawaii was severely tempered by what I observed in Kaluaa Gulch in the Waianae Range in the company of Derral Herbst and John Obata on 7 December 1975. I should first explain that the very first field trip I was on in Hawaii was in Kaluaa Gulch in September of 1969. At that time the gulch was literally packed with *Charpentiera*. It was in that gulch that I first came to appreciate the significant differences between *Charpentiera obovata* Gaudichaud and the taxon that was subsequently named as *C. tomentosa* var. *tomentosa* Sohmer; differences that were previously overlooked in the herbarium but were vividly apparent in that gulch during 1969-70 as one stood about equal in height to the shrubby *C. obvata* but had to walk in the shade cast by the tall and robust latter taxon.

The tragedy of the indigenous and endemic flora and fauna of the Hawaiian Islands were graphically illustrated for me on the relatively small stage represented by that gulch on 7 December. The gulch was practically devoid of both species. It took a little while to realize that the "skeletons" of shrubs and taller trees that one passed in the gulch were the living (?) evidence of the efficiency of the introduced borer which has threatened many indigenous species of plants. The borer had just begun its work in 1969, but at that time one could still believe that it would not have the effect that it has apparently had in Kaluaa Gulch. The only individual of *C. tomentosa* var. *tomentosa* still extant in the gulch proper was, by coincidence, the type individual (the individual from which the taxonomic type specimen was taken). However, the borer, by repeatedly destroying the apical meristems, the growing points of the stem, by, true to its common name, boring into the stem and excavating the interior, had just about exhausted the ability of the plant to regenerate itself. A few spindly branches were left, one of which was nearly ready to fall. Cuttings were taken of this branch in an effort to start the plant at the Lyon Arboretum, but it is doubtful, in my mind, whether they will take due to the damage the stem tissue has sustained. A few seedlings of *C. obovata* were found by John Obata, and in the forest off the ridge leading up to Puu Kanehoa a tree or two of *C. tomentosa* var. *tomentosa* were seen (the latter also infected by the borer). This, it appears, is what is left of the genus in that corner of the Hawaiian Islands--a very sad spectacle for an individual who spent a few years of his life working with them.

DO YOU HAVE DUES DUE?

With the last issue of the *Newsletter* most of you received notices that you owed dues for the current year and many of you also learned that our records showed that you owed dues for previous years. Several of you have sent checks accompanied by notes of apology for late payment, but it is really the Society that owes you the apology.

For some reason no dues notices were sent out during the past two years. Also, at some time in the past separate sets of membership cards were developed by the treasurer and the membership committee. Sometimes these cards have been maintained in different ways, and a few cases they differ regarding records of dues payment and current addresses.

Since the current treasurer and membership chairman occupy adjacent offices, we have decided to combine our files and maintain only one set of up-to-date records. The dues notices you received represented our best efforts to determine your obligations to the Society. We realize that some of our assessments may be in error, as errors are bound to creep into any system, and are much more likely to creep into a system which maintains separate and unequal dual files. Consequently, our sincere apologies to you for any erroneous assessments--please write or phone either of us to straighten things out. Henceforth, all dues received by the Society will be channeled through the membership chairman, who will keep the records updated, to the treasurer who will deposit the funds in the Society's account. All notices of address changes should be sent to the membership chairman. We hope that these changes will result in keeping mistakes to a minimum.

BUT--for those of you who still owe dues, current and/or back, we are still accepting payments gladly.

Charles Lamoureux, Treasurer
Lani Stemmermann, Membership Chairman

REPORT OF THE TREASURER FOR THE YEAR ENDED NOVEMBER 30, 1975

RECEIPTS		
Dues	$1010.25	
Interest withdrawn from Neal Account, First Federal S. & L.	700.00	
		$1710.25
EXPENDITURES		
Secretary's expenses (for stamps, etc.)	172.22	
Brochures, 50th Anniv. meeting	449.00	
Newsletter (incl. typing)	743.92	
Half of travel expenses for lecturer, May meeting	28.38	
Hawaii Science Fair Awards	31.80	
Outstanding Botany Student Award	35.91	
		$1461.23
		$ 249.02

Balances in banks and savings accounts as of November 30, 1975

First Hawaiian Bank Commercial Account

Bank Statement, Nov. 30, 1974	$ 389.35
Deposits, Dec. 1, 1974 - Nov. 30, 1975	1710.25
	$2099.60
Withdrawals, Dec. 1, 1974 - Nov. 30, 1975	1461.23
Bank Statement, Nov. 30, 1975	$ 638.37

First Federal Savings & Loan Ass'n
Marie C. Neal Memorial Account

Balance, Nov. 30, 1974	$12,329.74
Interest earned	636.51
	12,966.25
Withdrawals	700.00
Balance, Nov. 30, 1975	$12,266.25

First Federal S. &. L. Savings Account

Balance, Nov. 30, 1974	$127.13
Interest earned	6.85
Balance, Nov. 30, 1975	$133.98

It was with regret that on March 8 I tendered my resignation as editor of your *NEWSLETTER*, the result of a difficult decision necessitated by numerous other pressing commitments. This, then, will be my last issue.

Although my successor has not yet been selected, I do hope that all of our members and readers will give our future editor the cooperation so vitally needed.

I thank the Society for the opportunity to have served. It has been a most rewarding experience.

Bill Hoe
March 26, 1976

CHANGE IN MEMBERSHIP CATEGORY: *Mr. Charles H. Crispin* to Life Membership. Mahalo!

NAMES AND NOTES

For the past ten years, *Dr. Martin H. Zimmermann* (Professor of Biology at Harvard University) has worked on palm development with particular emphasis on the differentiation of vascular tissues and the transport of materials within them. He recently presented a film-and slide-illustrated siminar to the Botany Department entitled "How plam trees grow tall without secondary grothw."....In addition to speaking before the Society, *Dr. R. E. Holttum* (Royal Botanic Garden, Kew) presented a seminar to the Botany Department on "The present state of fern taxonomy." Dr. Holttum was in Hawaii to receive the first Allerton Award in recognition of his prominence in tropical plant taxonomy..."Foliage for food and chemicals" was the topic of yet another seminar presented to the Botany seminar by *Dr. G. M. Barton* (Western Forest Products Laboratory, Vancouver). Dr. barton described research being conducted in his laboratory on the use of leaf tissues as sources of food materials and of industrial chemicals.. According to an item in the November 5 issue of the Honolulu Star Bulletin, Castle & Cooke Inc. recently donated 127 acres of North Kohala land to the Pacific Tropical Botanical Gardens. This, their third research garden, is located in the Awini area of the Big Island....The December issue of the "Defenders of Wildlife News" is almost entirely devoted to Hawaii's living heritage. Numerous articles dealing with nearly every aspect of the natural history of the islands are supplemented by many color illustrations. Copies, at $2.00 each, many be ordered from: Defenders of Wildlife, 2000 N Street NW, Suite 201, Washington, D. C. 20036.....*Dr. Daphne Vince-Prue* (Plant Science Laboratories, University of Reading), who has been studying the effects of light on plant development for the past 25 years, recently spoke on the "Photophysiology of Flowering" at a botany research seminar...."The phytochemistry of the Guttiferae" was the subject of a recent reserach seminar by *Dr. M. U. S. Sultanbawa* of the University of Ceylon.

Contribution from S. Montgomery

MINUTES OF THE REGULAR MEETING OF JANUARY 5, 1976

The meeting was called to order by Dr. Derral Herbst, the past president because both the president and vice president were out of town. The minutes of the previous regular meeting were read and accepted. Twelve members and 8 guests were in attendance. Dr. Lamoureux presented the treasurer's report which was accepted by the Society (seen elsewhere in this issue). The auditor's report was presented by Dr. Herbst. Dr. Lamoureux moved that the auditor's report be accepted with thanks to Mr. Bell. Ron Hurov seconded. The report was unanimously accepted.

Dr. Lamoureux brought to the attention of the group the existence of an inactive savings account at First Federal Savings and Loan. After some discussion it was decided that after Dr. Lamoureux got the Society's affairs sorted out with IRS that the status of this account might be changed.

Dr. Herbst introduced the speakers, Mr. Steven L. Montgomery of Natural Areas Commission, Land and Natural Resources and Mr. Glen Spence, Lyon Arboretum. The subject of their presentation was "Natural Area Reserve Potential of the Puu Waawaa Dryland Forests, Hawaii."

John Obata showed some specimens of native plants he had grown in his yard and indicated that growing native plants under cultivation was much more difficult than it appeared.

Dr. Herbst adjourned the meeting at 9:15 p.m.

Evangeline Funk, Secretary

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
C/O DEPARTMENT OF BOTANY,
UNIVERSITY OF HAWAII,
HONOLULU, HAWAII 96822

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Contents

VOLUME 15 NUMBER 2 APRIL 1976

LICHEN DYES
by E. Justin Funk 31

SOME HAWAIIAN SPECIMENS IN LENINGRAD AND IN GENEVA
by Otto and Isa Degener 34

CULTIVATING AN "EXTINCT" SPECIES
by J. Obata 35

RECENT PACIFIC PUBLICATIONS - 3
by C. H. Lamoureux 37

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE REGULAR MEETING OF FEBRUARY 2, 1976

The meeting was called to order by the president, Dr. Gerald Carr, at 7:35 p.m. The minutes of the previous meeting were read and accepted.

The president suggested that Marie Neal's book, now in paperback, is not appropriate as a gift from the Society to Science Fair winners. Steve Montgomery suggested the Society give Dr. Rock's book, in hard cover, instead. Dr. Theobald volunteered to donate two copies of the Rock book to be given through the Society. Dr. Lamoureux moved that the Society accept the gift. Ted Green seconded the motion. The motion was carried.

The next order of business was honorary memberships. The president reported that the Executive Board has nominated five people for Honorary Membership. Dr. Lamoureux passed out ballots to fulfill the "in writing" stipulation in the By-Laws. All five were voted Honorary Memberships. They are Donald Anderson, Gladys Baker, Helen Baldwin, V. J. Krajina, and Lorraine Kuck.

Dr. Lamouruex presented the treasurer's report. He announced that Society membership dues should be paid forthwith and members should pay Lani Stemmermann. As of February 2, 1975 the Society has a checking account balance of $626.63.

Dr. Lamoureux reported to the Society, that should the need arise, members who in the future might want to testify before the Legislature must be registered as Lobbyists. Such Lobbyists must be approved by the president or the vice president. Members were asked to register.

Dr. Theobald offered sleeping space at the Pacific Botanical Garden dormitory to Society members who might be on Kauai during the first two weeks in September.

Wayne Gagné announced the publication of "A Field Guide to Birds of Hawaii" by the Hawaii Audubon Society. The price is $3.00.

The speaker for the evening was Betsy Gagné. She presented slides and spoke about the Gagné's upcoming sojourn in New Guinea.

The meeting adjourned at 9:05 p.m.

Evangeline Funk, Secretary

Volume 15, Number 1 was mailed June 4, 1976.

LICHEN DYES

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Lichens have been used to color fabric for almost as long as the human race has had the ability to create cloth. Today, in many parts of the world lichens are still used for dyeing cloth. The Indians of southwestern United States extract the colors by complicated processes that include heating, smoke, and fats gleaned from wool. In Norway and Ireland people engaged in the cottage trades of spinning and weaving extract dyes using rotted urine (1). Many of the lovely tones found in the handsome fabrics from Peru and Guatemala are obtained from lichens. Currently, as craftsmen return to the use of natural dyestuffs, interest in this ancient source is being revived.

People have found a variety of uses for lichens other than coloring. Some lichens can be eaten either fried or in soups. Some species of *Usnea* are gathered for the usnic acid found in them which is used as a topical antibiotic. In France the essential oils of lichens are used for perfume making. The amphoteric ingredient for the manufacture of litmus paper is obtained from a species of *Cladonia* (2). Today, scientists are studying lichens as indicators of air pollution. As air in urban areas becomes more and more polluted, the lichens die out. By mapping the distribution of lichens in and around cities information about sources, intensity and distribution of pollutants is obtained. As scientific interest in lichens grows, the possibility of finding new and important uses for these curious little "organism" will also grow.

The processes of extracting dyes from lichens are very simple. The only difficulty arises in finding the right species in sufficient quantity. Although many lichens produce weak phenolic and fatty acids, not all of these produce dyes. One of the best lichen-producing areas on O'ahu is the Wai-'anae Mountain Range, but for all practical purposes, that area is closed to the public. The next best hunting grounds are the dry areas of the Ko'olau Mountains. It cannot be overemphasized that not all lichens produce dyes. Do not go out and collect huge quantities on the off chance that some will be interesting. Lichens are extremely slow growing plants. A thallus of five or six centimeters may represent twenty or thirty years growing time. Indiscriminate harvesting could wipe out the lichen flora that would take a quarter century to recover. Over collecting would also undermine ongoing efforts to catalogue and identify the Hawaiian lichen flora. Finally, the islands would be really unfortunate to lose yet another group of Hawaiian plants. So, before you take a thallus, do a simple spot test that will indicate the presence of colors. Take along a small bottle of potassium hydroxide (KOH) with a dropper. Apply a drop of this solution to the thallus. If dye is present the reaction will be immediate. The spot will turn red, yellow, orange or whatever depending on what chemicals are present in the thallus. If there is no reaction do not bother to collect that lichen as it is of no use to you.

After you have gathered a sufficient quantity of lichen thalli (be careful not to mix species), clean then very carefully by removing all dirt and dead plant material. Tear them into small pieces and place the material in a glass jar big enough to hold the lichen and the fabric to be dyed. The jar must have a tight cover. Pour in enough solution to cover the plant material and the cloth. The solution is made of two parts pure water (rain water, distilled or deionized water) and one part household ammonia. Close the jar tightly and store. Once or twice a day stir or shake the mixture but, be careful not to get it on yourself or your clothing. If you do have an accident wash the affected area for five minutes in running water. After a week or two, when the desired color has been obtained, remove the fabric and rinse in lots of clear running water. Dry your newly dyed project in the shade, never in direct sunlight.

Another method used to extract lichen dyes is boiling. Simply place lichens and fabric in a glass or enameled pan with enough pure water to cover. Very gently boil the materials for several hours or until a satisfactory color has been obtained. Try both methods with a single species of lichen. You will be surprised at how different the colors produced by the two treatments can be.

Natural dyes are generally not as color fast as manmade or chemical dyes. Since considerable effort goes into the manufacture of lichen dyes a little extra effort can make them more longlasting and satisfying. Use a mordant. Before dyeing any fabric soak it in a solution made of Hawaiian salt and water. One heaped tablespoon of salt dissolved in one pint of water is fine. Soak the material in this mixture and dry it without rinsing. After the material has been dyed do not use strong detergents and never use bleach when washing. Materials dyed using lichens should be hand washed in luke-warm water and mild soap and dried away from the direct sunlight.

As a general rule, lichens do not produce intense colors. Warm earth tones are more to be expected. These dyes work best on animal fibers, such as wool. However, there are some exceptions and some of the following lichens produce intense colors that work equally well with either vegetable or animal fibers. There are no common names for lichens so brief descriptions follow the scientific names.

Parmelia tinctorum Nyl., with big grey, loosely-attached thalli, found on rocks at low elevations all over the islands is a good species for the novice craftsman. It produces a deep red-brown dye and is easily collected in sufficient quantity to be useful. Brown dyes of good quality can also be obtained from many lichens. *Parmelia caperata* (L.) Ach., a yellow-grey species found on rocks at higher elevations, *Parmelia cristifera* Tayl. and *Parmelia salacinifera* Hale both mineral grey and found growing on trees at low or medium elevations will produce good rich brown dyes.

The stringy, orange thallus of *Teloschistes flavicans* (Sw.) Norm. yields a good magenta. This lichen can be found atop the cliffs behind Waimanalo growing on rocks or along the rim of Koko Crater where it grows on tree branches.

A very good yellow dye can be obtained from *Parmotrema endosulphurea* (Hillm.) Hale, a light grey thallus with a bright yellow interior. This lichen can be found growing on tree branches in high wet areas. A somewhat softer yellow can be had from *Usnea rockii* Zahlbr., a fruticose lichen that is found growing on *Acacia koa* trees. A very light yellowish green, this lichen bears rather large, flattened disks that make it easily identifiable. It can be gathered in good quantity from fallen branches after heavy wind storms even at low elevations.

The yellow-speckled, brown foliose thallus of *Pseudocyphellaria aurata* (Ach.) Vain. can easily be overlooked because it appears to be dead. It is well worth seeking out because of the intense wine red dye that can be extracted from it. *P. aurata* can be collected in good quantity at low elevations in the Wai-'anae Mountains and along the ridges behind Ka-'a'awa where it grows on the ground and on small shrubs.

The thallus of *Cladonia skottsbergii* (Abb.) Evans yields a lovely soft pink. This yellowish-green lichen grows on the ground forming large, much-branched, pin cushion-like clumps. It is found in good quantity in the open woods along the summit trails of the Wai-'anae Mountains.

There is a myth that lichens from higher elevations produce the best colors. A more correct statement would be that some lichens from high elevations produce good colors, and so do some lichens from lower elevations.

If you do not find a particular lichen in sufficient quantity on one collecting trip, thoroughly dry what you have and store it away until you find some more. Lichens can be kept for very long periods without losing any of their dyeing properties.

Of the dozens of lichens tested, many others were found to contain dyes, but were found in such small quantities that at this writing they are considered useless for craft projects. There are literally hundreds of lichens to be found in Hawai'i and the likelihood of finding untried types that would be useful to craftsmen is limited only by one's ability to find them.

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(1) Hale, Mason E. 1969. *The Lichens*. Wm. C. Brown Co., Dubuque, Iowa.

(2) Hale, Mason E. 1967. *The Biology of Lichens*. Edward Arnold Ltd., London.

SOME HAWAIIAN SPECIMENS IN LENINGRAD AND IN GENEVA

Otto and Isa Degener
Volcano, Hawaii

During the XII International Botanical Congress we visited the Kamarov Botanical Institute in Leningrad, U.S.S.R. The Hawaiian plants deposited there include collections made during the 1815-1818 voyage of the Brigg Rurick under Captain Otto von Kotzebue who was attempting to discover a Northwest Passage through the Bering Strait. The late Dr. Earl E. Sherff some decades ago borrowed Chamisso's collection from Leningrad, studied the genera in which he was then interested, and mailed the collection for annotating to Otto Degener at the New York Botanical Garden. After study, Degener mailed the collection back to Leningrad. An outstanding sheet was one of *kauna'oa-pehu* (*Cassytha filiformis* L.), parasitic on a few leaves of Oahu's endemic and now extinct *koki'o* (*Kokia lanceolata* Lewt.). A partial collection of Chamisso's Hawaiian specimens, by the way, are in Berlin-Dahlen, Germany.

In a recent note (Degener and Degener 1973), we mentioned that Dr. Paul Aellen and wife Suzanne Aellen-Meisel had obtained by gift and purchase from the Degeners over the years a large collection of Hawaiian herbarium specimens. These they kept in their home in Basel, Switzerland with Dr. Aellen's Chenopodiaceae and other plants. According to a letter from W. Greuter, dated August 14, 1975, "After Paul Aellen's death, the collections (herbarium and library) of the '*Stiftung Paul Aellen*' have been transferred to the Conservatoire Botanique of Geneva where they constitute a separate unit."

What Hawaiian worker of the future, unaware of this notice, will ever suspect that in some lonely cabinet in Geneva reposes the type of Molokai's *Chenopodium pekeloi* Degeners & Aellen, and many critical cotypes collected in our Islands? The more practical way of honoring this botanist, we believe, is not' to keep his collection out of the "mainstream" of research by hiding it. Rather each sheet should be stamped as belonging to the Aellen Herbarium and intercalating it in the general herbarium of the institution for convenient and instant use.

Monographers of Hawaiian taxa are here alerted that unique collections are available in Leningrad and Geneva. These must be studied for the proper understanding of recently extinct and still extant taxa of Hawaii.

REFERENCE

Degener, O. and I. Degener. 1973. Paul Aellen-Meisel. Newslett. Hawaiian Bot. Soc. 12(5): 31.

CULTIVATING AN "EXTINCT" SPECIES

J. Obata

On May 25, 1975 while hiking along the ridge to 'Ōhiki-lolo, in the Wai-'anae Range on O'ahu, it was my privilege, for the second time, to observe a colony of *Tetramolopium filiforme* Sherff, a member of the aster family. However, *Tetramolopium filiforme*, endemic to O'ahu, was supposed to be extinct -- according to the *Federal Register* (1975). Dr. W. F. Hillebrand seems to have been the last to collect this plant about a hundred years ago. Dr. Earl Bishop supposedly collected some vouchers a few years ago from the same area.

Because of this plant's rarity, let alone its beauty, I collected some seeds, hoping to propagate the plant as a potential horticultural gain. Dr. Derral Herbst, who was my companion for the day, sent others seeds to the University of California at Davis where chromosomal studies are being carried out and to Mr. Keith Woolliams of the Wai-mea Arboretum, O'ahu, for further propagation. The germination and growth at both institutions are encouraging. One of my plants has bloomed. This note summarized some casual observations on the life cycle of *T. filiforme* based on one horticultural specimen to give interested persons a better insight into this species.

The seeds were planted on May 26, 1975 in a small, flat, plastic tray. Red Moloká'i cinders were placed in the bottom half of the tray while the upper half was filled with a mixture of vermiculite, fir bark and peat. The surface was sprinkled with hāpu'u (*Cibotium*) fibers. In about three weeks the seeds germinated. Nine seedlings survived for about two weeks and then wilted save two. These two wilted a few days after being transplanted into a similar medium a few weeks later. Four weeks after the first germination, three more seeds germinated. One seedling wilted *in situ* while another wilted in transplant. The remaining seedling was left to mature in the plastic tray.

After the wilting of the first group of germinants, a program of heavy fungicide and bactericide treatment was initiated. This treatment probably saved the remaining plant. Also, it was found that the medium must be kept wet at all times even though this *Tetramolopium* is a true xerophyte in its natural habitat.

Fifteen weeks after germination, this 9cm (3.5in) high plant produced its first bud. In two weeks each of the five branches produced five buds each. The first blossoms were noted about eighteen weeks after germination.

The phenology of the inflorescence was rather interesting. Some buds had persisted for about eight weeks without blooming. In most cases the center bud developed rapidly then awaited the development of the other four buds in the cluster and all the buds bloomed simultaneously. Three to four days after the ray flowers bloomed, the disk flowers opened in unison. The ray flowers opened with a pinkish-lavender hue and became whitish in about two days. Then the disk flowers bulged and opened to present a rather unsightly flower. The corollas persisted up to about ten days. The seeds matured in fifteen to twenty days after the ray flowers opened. Some flowers did not develop completely.

The growth habit is rather interesting. The inflorescence forms at the apex of each shoot while the new shoots develop laterally on the shoot (i.e. a monochasial sympodium). The apices of each of these new shoots eventually produce pedicels and new stems again developed on the outside of the pedicel bases. The new branches did not produce the five inflorescences seen during the initial flowering period. The new set of floral buds appeared four weeks after the first set.

Judging from the number of branches noticed on wild plants, the species do not seem to be long-lived if size and number of branches are considered. The cultivated plant is still growing and flowering after 18 months. However, the plants normally live in an arid, hostile habitat and may go into seasonal dormancies during the dry summer and autumn months. Contrary to their seasonal blooming periods observed in their natural habitat, this plant blooms continuously under greenhouse conditions. Wild plants seem to flush out only after a good downpour.

There are problems in cultivating this rare plant. In its natural habitat, it is a very striking plant with or without its inflorescence. It looks like a miniature bonsai. Under greenhouse conditions, its leaves look somewhat necrotic and lack the vigor and beauty of its wild counterpart. It wilts and dies with the slightest disturbance to its root system. Overwatering or dessication in cultivation kill the plant. Fungicides must be used constantly and consistently to insure survival. Perhaps with enough seedlings, a resistant clone might appear to perpetuate this species. Till then this plant, once considered extinct, is surviving on an arid, open, rocky ridge top. Its survival in such a situation is a natural phenomenon in itself.

LITERATURE CITED

Anonymous. 1976. Endangered and Threatened Species. Plants. *Federal Register*. 16 June 1966. 24524-24572.

RECENT PACIFIC PUBLICATIONS - 3

C. H. Lamoureux
Department of Botany
University of Hawaii - Manoa

ALDRICH, W. W. and H. Y. Nakasone. 1975. Day versus night application of calcium carbide for flower induction in pineapple. Jour. Am. Soc. Hort. Sci. 100: 410-413.---Under experimental conditions virtually 100% flowering was induced by a single night application of a small piece of dry calcium carbide in water in the center of the plant. Single applications of either dry carbide or acetylene during daylight gave very little flowering, except when applications were made just before or just after sunrise. A repeat application, 3 to 5 days after the first, increased the amount of flowering.

BAAS, P. 1975. Vegetative anatomy and the affinities of Aquifoliaceae, Sphenostemon, Phelline, and Oncotheca. Blumea 22: 311-407.—Includes brief description of leaf anatomy of the Hawaiian *Ilex anomala*.

CLEMENTS, H. F. 1975. Flowering of sugarcane: Mechanics and control. Hawaii Agr. Expt. Sta. Tech. Bull. 92. 56 p.---Describes morphological aspects of floral induction, and environmental factors which influence floral induction. Describes techniques for preventing or reducing flowering under field conditions, and techniques for inducing flowering under artificial conditions.

CRILEY, R. A., T. S. Kunimitsu, P. E. Parvin, and J. L. Degan. 1976. Ground cover survival and growth. Univ. Hawaii, Coll. Trop. Agr., Hawaii Agr. Expt. Sta., Dept. Paper 12. 8 p.---Gives evaluations of survival and growth of 75 ground covers at three sites on Oahu (Waimanalo Research Station, Sandy Beach Botanic Garden, Kahuku High School) and one site on Maui (Kula Experiment Station).

DEGENER, O. and I. Degener. 1975. *Rapanea*, Myrsinaceae, in the Pacific. Phytologia 31: 21.---Propose the name *Rapanea hendersonensis* Deg. & Deg. for the plant from Henderson Island originally named *Myrsine hosakae*.

DEGENERS and Sunadas. 1976. *Argyroxiphium kauense*, the Kau silversword. Phytologia 33: 173-177.---Detailed description with photographs, and notes on distribution and status. (Note: only author's surnames are given in the usual place; a footnote indicates that the authors are "Mr. & Mrs. Otto Degener, botanists; Mr. & Mrs. Kaoru Sunada, wholesale florists").

DE WIT, H. C. D. 1975. Typification of *Leucaena leucocephala* (Lam.) de Wit, *Lysiloma latisiliquum* (L.) Bth., and *Acacia glauca* (L.) Moench. Taxon 24: 349-352.---Another chapter in the saga of the correct botanical name for koa haole. The conclusion of this paper is that the correct name for this ubiquitous plant is *Leucaena leucocephala* (Lam.) deWit, and that the name *Leucaena latisiliqua* (L.) Gillis, although an older name, was based on a different species, not on koa haole.

FOSBERG, F. R. 1975. The deflowering of Hawaii. National Parks & Conservation Mag., Oct. 1975: 4-10.---Discusses the factors responsible for the rapid disappearance of the native Hawaiian flora in the past 2 centuries, and assesses the chances of protecting what remains of it.

----- and M.-H. Sachet. 1975. Flora of Micronesia, 1: Gymnosperms. Smithsonian Contrib. Bot. 20: 1-15.---Includes a brief introduction to the flora of Micronesia. Floristic taxonomic treatments with keys, synonymy, descriptions, distribution, ethnobotany and vernacular names, and citations of geographic records and herbarium specimens are provided. Seven families of gymnosperms are treated.

----- and -----. 1975. Polynesian Plant Studies 1-5. Smithsonian Contr. Bot. No. 21. 25 p.---Part 1 - *Vaccinium cereum* in Tahiti and the Marquesas. 2. *Myrsine* in Eastern Polynesia. 3. New species of *Geniostoma*: *G. hallei* from the Marquesas, *G. quadrangulare* from Rapa. *G. astylum* from Tahiti is described in greater detail. 4. *Ipomoea tiliacea* in the Pacific. New variety *merremioides* from the Marquesas, and new var. *smithii* from Fiji and Tonga are described. 5. Annotations to the Hawaiian flora. New records for the Hawaiian flora include *Carex ovalis, Cyperus niger, Salicornia virginica, Dianthus prolifer, Rubus moluccanus, Lotus hispidus, Polygala paniculata, Frankenia grandiflora, Dissotis rotundifolia, Parentucellia viscosa, Tetranema mexicanum, Plantago debilis*. Plants removed from the Hawaiian flora, on the basis of earlier misinterpretations are: *Solanum repandum, Plantago psyllium*. Notes are given for *Adiantum raddianum, Dianthus armeria, Bocconia frutescens, Rubus ellipticus, Crotalaria pallida, Melochia umbellata, Waltheria indica, Thevetia peruviana, Heliotropium anomalum, Stenogyne scrophularioides, Hedyotis corymbosa*. Key to introduced species of *Plantago*.

----- and -----. 1975. Flora of Micronesia, 2: Casuarinaceae, Piperaceae, and Myricaceae. Smithsonian Contr. Bot. 24: 1-28.---Treats 1 species of *Casuarina*, 11 of *Peperomia*, 8 of *Piper*, 1 of *Myrica*. Of special interest is the conclusion that the plant long known as *Casuarina equisetifolia* L. should be known by the earlier name of *C. litorea* L.

GILLETT, G. W. 1975. The diversity and history of Polynesian *Bidens*, Section Campylotheca. Univ. Hawaii: H. L. Lyon Arboretum Lecture No. 6: 1-32.---Among 18 Polynesian species, 42 experimental interspecific hybrids have been produced, and many natural hybrids reported. All F_1 and F_2 hybrids among Hawaiian species were fertile. Hawaiian X Marquesan crosses produced vigorous but sterile F_1 hybrids.

Author suggests that genetic evidence justifies merging 42 Hawaiian species into 1 species with 7 subspecies (but the appropriate nomenclatural combinations are not published). It is suggested that *Bidens* migrated from North America to Hawaii, underwent extensive adaptive radiation in Hawaii, from which dispersal to southern Polynesia occurred.

GRANT, M. L., F. R. Fosberg, and H. M. Smith. 1974. Partial flora of the Society Islands: Ericaceae to Apocynaceae. Smithsonian Contr. Bot. 17: 1-85.---Flora based largely on collections made by MLG in 1930-31, with subsequent work on other collections. The floristic study was prepared in manuscript form by MLG, and completed after his death by FRF, who also supplied a brief biographic sketch of MLG. About 1/3 of the publication consists of a history of the botanical exploration of the Society Islands prepared by HMS. Plant families treated are: Ericaceae, Epacridaceae, Myrsinaceae, Primulaceae, Plumbaginaceae, Sapotaceae, Ebenaceae, Styracaceae, Symplocaceae, Oleaceae, Loganiaceae, Gentianaceae, Apocynaceae.

HIGA, T. and P. J. Scheuer. 1974. Hawaiian Plant Studies. Part XVI. Coumarins and flavones from *Pelea barbigera* (Gray) Hillebrand (Rutaceae). J. Chem. Soc. Perkin Trans. I: 1350-1352.---Describes and characterizes 3 known coumarins, a new furocoumarin, and 2 new flavones.

----- and -----. 1974. Alkaloids from *Pelea barbigera*. Phytochemistry 13: 1269-1272.---Describes and characterizes 2 alkaloids, the first known from *Pelea*.

HOE, W. J. 1975. Additional new and noteworthy records for Hawaiian mosses - 3. The Bryologist 78: 359-360.---Three mosses new to the Hawaiian Islands are reported: *Barbula unguiculata, Bryum pseudocapillare, Rhabdoweisia crenulata.* Also, 13 new island records are reported.

-----. Bryophyta Hawaiica Exsiccata. (See H.B.S. Newsletter 14: 77).---Series I, Decade 4, and Series I, Decade 5, were distributed in October 1975.

HOLDSWORTH, D. 1975. Traditional medicines of Papua New Guinea. South Pac. Bull. 25(4): 32-35.---Illustrated introductory article on indigenous medicinal uses of *Alstonia scholaris, Cassia alata, Erythrina variegata, Hibiscus tiliaceus, Morinda citrifolia* and *Securinega virosa*.

KALLIO, P. and S. Heionen. 1973. Ecology of *Rhacomitrium lanuginosum* (Hedw.) Brid.---(author's abstr.) "Net photosynthesis and its dependence on temperature, light and moisture have been studied in *Rhacomitrium lanuginosum* (Hedw.) Brid. strains from Spitsbergen, Finnish Lapland, S. Finland, W. Norway, the British Isles, Austrian Alps and from S. Georgia. The effect of freezing was also studied. The optimum temperature in high light intensities of 12000-15000 lux was around +5°C, and the minimum -8° to -10°C in all the different strains. The maxima show larger variation between around +25° to +30°C in short-time experiments The activation after low temperature of

-30°C is very rapid--around 60% during the first three hours in all strains. It seems that there are hardly any forms clearly adapted to e.g. arctic and temperate regions in this very cosmopolitan moss, as regards the temperature. The moss is "preadapted" to a very wide ecological temperature variation. Moisture conditions must be very important to the distribution of this plant. The rhythm of light may have some significance as an ecological factor, and the high demand of light restricts the habitats to open rocks and bogs. Comparisons are made to *Pleurozium schreberi*.

W. J. Hoe comments "*Racomitrium lanuginosum* (usually as the variety *pruinosum* although many authors do not recognize the variety) is widespread in the high-elevation bogs on Kauai and Molokai and is the most abundant moss at high elevations on Maui and Hawaii Island."

LLOYD, R. M. 1974. Mating systems and genetic load in pioneer and nonpioneer Hawaiian Pteridophyta. Bot. J. Linn. Soc. 69: 23-35.---Species dominant in pioneer lava habitats were found to have intragametophytic mating systems and to be devoid of lethal genotypes. Species from intermediate and mature rain-forest habitats exhibited complex intergametophytic mating systems and high levels of genetic load. It is suggested that natural selection has favored intragametophytic mating and homozygosity in species of less diverse and less competitive habitats and intergametophytic mating and heterozygosity in species of more mature habitats.

MABBERLEY, D. J. 1975. The giant lobelias: pachycauly, biogeography, ornithophily and continental drift. New Phytol. 74: 365-374.---Suggests that Hawaiian lobelias of the Galeatella group (e.g., *Lobelia gaudichaudii*; the group of species treated by the Degeners as the genus *Galeatella*) has affinities with South American lobelias, as does the genus *Trematolobelia*. On the other hand, the Revolutella group (e.g., *Lobelia yuccoides*; the Degeners' genus *Neowimmeria*) is interpreted as having its closest affinities with Asian lobelias.

MACIOLEK, J. A. 1975. Limnological ecosystems and Hawaii's preservational planning. Verh. Internat. Verein. Limnol. 19: 1461-1467.---A brief inventory of the natural limnological resources of Hawaii (streams, lakes, pools, ponds, marshes), with mention of some of the unusual biota they contain, as well as a summary of proposals for natural area reserves which have significant limnological components.

MONTGOMERY, S. L. 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proc., Hawaiian Ent. Soc. 22: 65-103.---Studies of about 80 species of picture-winged *Drosophila* have shown most of them to be host-specific to a certain plant family. The Araliaceae were used as breeding sites by 37% of the species studied, the Lobeliaceae by 15%. Other plants which seem to be of special importance are: *Touchardia* and *Urera* (Urticaceae); *Charpentiera* (Amaranthaceae) and *Pisonia* (Nyctaginaceae); *Freycinetia* (Pandanaceae); *Dracaena aurea* (Liliaceae).

MUELLER-DOMBOIS, D. and G. Spatz. 1975. The influence of feral goats on the lowland vegetation in Hawaii Volcanoes National Park. Phytocoenologia 3: 1-29.---Experiments with exclosures indicate that one vegetation type which is widespread in the coastal parts of the Park (*Eragrostis tenella* grassland), and the localized grass/scrub community on deep ash at Puu Kaone are entirely goat-derived vegetations. Recovery of areas from which goats are excluded occurs rapidly, and indicates at least a partial return of native vegetation in the area.

----- and -----. 1975. Application of the relevé method to insular tropical vegetation for an environmental impact study. Phytocoenologia 2: 417-429.--The relevé method was used to assess environmental impact of SO_2 emissions from an electrical generating plant at Kahe Point, Oahu. No SO_2 damage was noted among vascular plants during the dry season. There was however, only about half the total lichen cover on rocks downwind of the generator than on comparable sites upwind of the generator.

PEARCY, R. W. and J. Troughton. 1975. C_4 photosynthesis in tree form *Euphorbia* species from Hawaiian rainforest sites. Plant Physiol. 55: 1054-1056.---No plants previously reported to possess the C_4 photosynthetic pathway were species of mesic or wet forests. Study of 19 Hawaiian and 2 Pacific island taxa of *Euphorbia* sect. *Chamaesyce* showed that all exhibited the biochemical ($^{13}C/^{14}C$ isotope ratios) and morphological (Kranz leaf anatomy) attributes of C_4 plants. Several of the taxa are shrubs and small trees in wet forests.

PURSELL, R. A. and W. J. Hoe. 1975. *Fissidens nothotaxifolius* (Bryopsida: Fissidentaceae). A new species from the Hawaiian Islands. The Bryologist 78: 476-480.---An endemic allied with one from Japan and another from eastern North America. Known from several localities on Kauai, Oahu, Molokai, Maui, and Lanai.

ROBERTSON, K. R. 1974. *Jacquemontia ovalifolia* (Convolvulaceae) in Africa, North America, and the Hawaiian Islands. Ann. Missouri Bot. Gard. 61: 502-513.---The endemic Hawaiian beach vine pa'ū-o-hi'i-'aka is considered to represent a subspecies of a wide-ranging species, and is named as *Jacquemontia ovalifolia* subsp. *sandwicensis* (A. Gray) Robertson.

ROBINSON, H. 1975. The mosses of Juan Fernandez Islands. Smithsonian Contr. Bot. 27: i-iv, 1-88.---(author abstract, in part): "Keys and descriptions are presented for the mosses of Juan Fernandez Islands. A total of 129 species are recognized in 73 genera and 32 families. Thirty-three of the species (about 25 percent) are endemic." Of particular interest to Hawaiian botanists is his discussion of the *Racomitrium crispipilum-R. crispulum* complex (the taxon is usually also recognized from Hawaii under the latter name although the author places Hawaiian material under the former), his non-recognition of the var. *pruinosum* of *Racomitrium lanuginosum*, and the new combination *Amphidium tortuosum* (Hornsch.) Robins. replacing *Amphidium cyathicarpum* (Mont.) Brid.

SACHET, M.-H. 1975. Flora of the Marquesas, 1: Ericaceae-Convolvulaceae. Smithsonian Contr. Bot. 23: 1-34.---Following a brief discussion of the history of Marquesan botany is the first installment of a new flora of the Marquesas, which contains floristic taxonomic treatments, keys, synonymy, descriptions, distribution, ethnobotany and vernacular names, and citations of geographic records and herbarium specimens. Families included in this part are: Ericaceae, Epacridaceae, Myrsinaceae, Primulaceae, Plumbaginaceae, Sapotaceae, Oleaceae, Loganiaceae, Gentianaceae, Apocynaceae, Asclepiadaceae, Convolvulaceae.

SAKAI, W. S. and M. Hanson. 1974. Mature raphid and raphid idioblast structure in plants of the edible aroid genera *Colocasia*, *Alocasia*, and *Xanthosoma*.---Describes the structure of the capsules which contain the needle-like raphid crystals that give raw aroids their acrid nature. The mechanism of release of the crystals is shown to be different in *Colocasia* than in *Alocasia* and *Xanthosoma*. The crystals differ in size and structure among the 3 genera, but all crystals are needle-like, with one end tapering to an elongate point, the other end to a short, abrupt point. All crystals bear tiny barbs on the surface with tips oriented away from the tapering end of the crystal. All crystals have a pair of deep lengthwise grooves, and in cross-section views are H-shaped.

SKOLMEN, R. G. 1975. Shrinkage and specific gravity variation in robusta eucalyptus wood grown in Hawaii. U.S.D.A. Forest Serv. Res. Note PSW-298. 6 p.--In a sample of 1691 pieces of wood from 50 plantation-grown *Eucalyptus robusta* from ten stands on the island of Hawaii, specific gravity and shrinkage values increased with distance from the pith and with tree height. Typical specific gravity ranges were 0.47 to 0.68; typical percent volumetric shrinkage, green to oven-dry, ranges were 10.3 to 15. It is suggested that by selecting boards according to locations in the tree, it is possible to decrease the variation when more uniform material is needed for a particular use.

SMITH, A. C. 1975. The genus *Macropiper* (Piperaceae). Bot. Jour. Linn. Soc. 71: 1-38, pl. 1-11.---Monographic. As here treated the genus includes 9 species and is restricted to Pacific islands.

-----. 1975. Studies of Pacific Island plants, XXX. Notes on Fijian Apocynaceae and Asclepiadaceae. Brittonia 27: 151-164.---In Apocynaceae a new combination, *Alstonia pacifica*, is proposed. In Asclepiadaceae a key to the genera with indigenous Fijian species is provided, and the species of *Tylophora* are reviewed. New combinations proposed are *Leichardtia stenophylla* and *Tylophora subnuda*.

----- and S. P. Darwin. 1975. Studies of Pacific Island plants, XXXI. Notes on Fijian Sapotaceae. Brittonia 27: 165-171.---New species described are: *Planchonella sessilis*, *Palaquium porphyreum*, *Burckella parvifolia*. One new combination is proposed, *Burckelia fijiensis*.

SPATZ, G. and D. Mueller-Dombois. 1975. Succession patterns after pig digging in grassland communities on Mauna Loa, Hawaii. Phytocoenologia 3: 346-373.---Effects of feral pigs were studied by following succession in plots disturbed by pigs as well as in artificially scalped plots. The data indicate a great increase in the component of introduced species in communities with a former high percentage of native species after pig digging.

ST. JOHN, H. 1975. The variability of the Hawaiian maile (*Alyxia olivaeformis*), Apocynaceae. Hawaiian Plant Studies 49. Phytologia 32: 377-386.---Describes and names 13 forms of maile, based on leaf shape. Provides key and illustrations. Three of these forms were previously described as varieties, the others are here described as new.

-----. 1976. Evaluation of *Waltheria indica* L. and *W. americana* L. (Sterculiaceae). Pacific Plant Studies 28. Phytologia 33: 89-92.---After study of the Linnean types, author has concluded that there are no clear differences between the two species, and that they should be considered as a single species called *W. indica*. Also reduces *W. pyrolaefolia* Gray, previously thought to be a Hawaiian endemic, to *W. indica*.

UHE, G. 1974. The composition of the plant community inhabiting the Green Lake crater, Raoul, Kermadec Islands. Tropical Ecology 15: 119-125.---Report on plants inhabiting recent volcanic substrates, derived from eruptions in 1872 and 1964. Comparisons with plants in similar habitats on other Pacific islands including Hawaii.

-----. 1974. The composition of the plant communities inhabiting the recent volcanic ejecta of Niuafo'ou, Tonga. Tropical Ecology 15: 126-137.---Includes studies made on lava and ejecta from eruptions in 1912, 1929, 1946, and 1953.

-----. 1974. The composition of the plant communities inhabiting the recent lava flows of Savii, Western Samoa. (Savii is a misprint for Savaii) Tropical Ecology 15: 140-151.---Reports on the Aopo flow of about 1760, the Maugu Mu and Mate o le Afi flows of 1902, and the Matavanu flow of 1905-1911.

WALTERS, G. A. 1975. Slow-release fertilizer aids early growth of Australian toon and Queensland-maple in Hawaii. Tree Planters' Notes 26 (3): 12-13.---Tree seedlings, treated at time of planting with Osmocote fertilizer, were significantly taller after one and two years than controls (no fertilizer), and seedlings treated with MagAmp and Quick Release fertilizers, at 2,620 ft. elevation in the Waiakea Forest Reserve.

WHITESELL, C. D. 1975. Growth of young saligna eucalyptus in Hawaii: 6 years after thinning. U.S.D.A. Forest Serv. Res. Note PSW-299. 3 p. ---A 6-year-old plantation of *Eucalyptus saligna* on Maui was thinned to give 3 levels of stocking (23 sq m basal area/ha; 19.5 sq m/ha, 16 sq m/ha). After an additional 6 year growth period no significant differences in growth response among treatments were found. Basal area values increased at about the same rate (13 to 15 sq m/ha) over the 6 year period. Mean annual volumetric increments were about 21 cu m/ha both before and after thinning.

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
C/O DEPARTMENT OF BOTANY,
UNIVERSITY OF HAWAII,
HONOLULU, HAWAII 96822

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Contents

VOLUME 15 NUMBER 3 JUNE 1976

THE GENERA *CHARPENTIERA* AND *CHAMISSOA* (AMARANTHACEAE) DISTANT COUSINS AT BEST
by S. H. Sohmer 49

THE ELUSIVE KAUILA (*ALPHITONIA PONDEROSA*) OF O'AHU
by John Obata 52

BRIEF REPORTS AND NOTES

SOCIETY BUSINESS...46; *Degener & Degener* - PINK-AND-WHITE SHOWER...48; *Conant* - TESTIMONY...53,54; *Gay* - TESTIMONY...55; *Degener & Degener* - BOOK REVIEW...57, 58; RECENTLY COMPLETED THESES...59.

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE REGULAR MEETINGS

The regular meeting of April 5, 1976 was called to order at 7:30 p.m. Twenty-seven members and six guests were present. The minutes of the February meeting were accepted as read.

Dr. Lamoureux gave the treasurer's report and noted there was a balance of $708.00.

The President, Dr. Carr, asked for a volunteer to take over the job of editor of the Newsletter because Mr. W. J. Hoe no longer has the time. There were no volunteers.

Dr. Carr stated that anyone who chooses to lobby for the Society must get the approval of at least two board members on any testimony before it is given.

Honorary members Lorraine Kuck, Helen Baldwin, Gladys Baker and V.J.K. Krajina expressed thanks for having been elected to honarary membership.

Dr. Conant announced several, upcoming meetings of the Audubon Society.

Ms. D. Peterson announced that several undergraduate students had received a National Science Foundation Grant to do research on Maui this summer and invited the membership to visit the site.

The meeting adjourned at 7:55 p.m.

Mr. Glenn Teves presented a talk on Ornamental Horticulture in Denmark.

. . . .

The regular meeting of May 3, 1976 was called to order at 7:40 p.m. Minutes of the April 5 meeting were read, corrected and accepted.

The Treasurer's report was read and accepted. Ted Green expressed his thanks to the members for their donations of plants for redistribution.

It was announced that the awards given by the Society at the recent Hawaiian Science and Engineering Fair were for projects on 'The Digestion of Toxic Substances from the Crown Flower by the Monarch Butterfly' and 'The Benefits of Nut Grass'.

The Public hearings on the proposed dredging of Honolulu and Barber's Point Harbors were called to the attention of the Membership.

Dr. Clifford Smith will be the new editor of the Newsletter.

Dr. Lamoureux spoke on the proposed new road through the Pacific Tropical Botanical Garden on Kauai and suggested that members be alert to similar projects.

Members were encouraged to start plants for the next plant donation and that possibly a calabash be placed by the punch bowl to encourage members to help pay for refreshments.

A member asked if the Hawaiian Hibiscus Society was still active. No information was available.

Dr. Sheila Conant proposed that a committee, within the Botanical Society, be formed to stimulate public interest in native Hawaiian plants, especially rare and endangered species. To educate the public about these plants, to record information on rare and endangered species so their distributions might be better understood. It was moved and seconded that such a Committee be formed, the chairman of which to be appointed by the president. The motion was unanimously passed.

Dr. Conant proposed a resolution to be addressed to the Board of Land and Natural Resources calling for the removal of feral sheep from Mauna Kea and the establishment of some comprehensive plan for the number of telescopes to be built on the mountain. The resolution was moved, seconded and passed with one dissenting vote.

Ron Hurov spoke on certain forestry practices in South America where native forests were being removed to create a monoculture timber industry. He pointed out that many minor forest products were generally more valuable than the timber.

Keith Woolliams urged members to support the IUCN, International Union for the Conservation of Nature which seeks to set aside natural areas and to protect those areas from such forestry practices.

It was suggested that the Committee for Native Hawaiian Plants might like to consider writing to the Hawaii State Legislature and to candidates running for office this year regarding forestry practices in Hawaii.

The question of Ohia die-back was raised. There are presently several people working on the problem and as yet no answer has been found.

The membership was asked for input on a plan for recreational utilization of certain areas on Oahu. Members were urged to participate on an individual basis.

The meeting was adjourned at 8:30 p.m.

Sheila Conant introduced Dr. Keith Woolliams who spoke on the future plans for the Waimea Arboretum.

. . . .

The regular meeting of June 7, 1976 was called to order by the president at 7:30 p.m. The minutes of the May meeting were read and accepted. Dr. Carr read letters of thanks from the recipients of awards given by the Society at the recent Science Fair.

Lani Stemmerman read the treasurer's report and announced the program for the upcoming Audubon Society meeting.

Dr. Carr announced that Dr. D. Palmer has agreed to serve as chairman of the Committee on Native Plants.

There being no further business the meeting was adjourned at 7:40 p.m.

Miss B. Krauss introduced Oscar Kirsch who presented a very interesting slide show and talk about Orchids in Hawaii.

Evangeline Funk, Secretary

THE PINK-AND-WHITE SHOWER

Otto and Isa Degener
Volcano, Hawaii

Kai Larsen and Supee Larsen (1974) state that "During the revisional work on the genus *Cassia* two new combinations have been made." They quote de Wit (1955), who states that "like most authors I am not entirely convinced of the right standing of *C. nodosa* as a species separate from *C. javanica*. It is our experience that it is not always possible to separate the two taxa on herbarium material. We have therefore chosen to treat them as subspecies as follows:

C. javanica Linn., Sp. Pl.: 379. 1753
  subsp. *javanica*
  subsp. *nodosa* (Buch.-Ham. ex Roxb.) K. & S. Larsen comb. nov.
    (Basionya: *C. nodosa* Buch.-Ham. ex Roxb., Fl. Ind. ed.
    Carey 2: 336. 1838)."

Degener (1932) remarked that "Hillebrand in his flora records both *Cassia javanica* and *C. nodosa* as growing in the Hawaiian Islands. He was in error. These two scientific names do not apply to two distinct species: *C. nodosa* is a synonym of *C. javanica* or, more likely, is the incorrect name of a plant that should be called *Cassia javanica* var. *nodosa*."

These two opinions, similar though over forty years apart, are not in agreement as to precise shape of leaflets.

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THE GENERA *CHARPENTIERA* AND *CHAMISSOA* (AMARANTHACEAE) DISTANT COUSINS AT BEST

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The biota of oceanic islands contain a considerable array of evolutionary phenomena. Carlquist (1966a, 1966b, 1966c, 1966d, 1967) rekindled an interest in the evolution of oceanic island biota initially fired nearly a century ago by Wallace (1881). One of the most interesting aspects of such a biota is its derivation. The chance long-distance dispersal of the progenitors of the present-day biota to relatively competition-free habitats is the basis for the most interesting aspects of insular evolution. Fosberg (1948) estimated the derivation of the vascular flora of the Hawaiian Islands by relating the indigenous taxa to one of several source areas. The present paper discusses the relationship between the genera *Charpentiera* and *Chamissoa* in the Amaranthaceae first implied by Hillebrand (1888).

The family Amaranthaceae consists of about 65 genera and approximately 800 species. There are several large genera in the family but most are small and nearly a third are monotypic. Hans Schinz (1934) was the last individual to attempt a treatment of the entire family. His classification scheme treated the family as consisting of two subfamilies (Amaranthoideae and Gomphrenoideae) and four tribes (Celosiae, Amarantheae, Brayulineae, and Gomphreneae). *Charpentiera* and *Chamissoa* are in the subtribe Amaranthineae of the tribe Amarantheae together with *Bosea, Allmania, Indobanalia, Apterantha, Lagrezia, Amaranthus, Acnida, Acanthochiton,* and *Digera*. This subtribe is delimited from the other members of the family in Schinz's treatment by the 4-celled anthers, and the 1-seeded, basally placentated ovaries. The system, however, breaks down below the level of subtribe. One of the major characteristics used by Schinz to delineate genera within the Amaranthineae is the nature of the floral sex. He separated genera which were supposed to contain polygamodioecious species from those whose members produced bisexual flowers. Several of the genera, including *Charpentiera*, cannot fit into this system, for although considered by Schinz to have bisexual flowers, they are actually dioecious or gynodioecious. *Allmania* and *Chamissoa* are obviously closely related because of the production of arils, but relationships between the other genera of the subtribe cannot be adequately assessed given the present state of our knowledge of the family.

Chamissoa and *Charpentiera* do indeed sometimes bear a superficial resemblance to one another that could be misleading in the herbarium at first glance, particularly if one assumes that the habit differences between the two are the result of evolutionary changes that occurred after the isolation of *Charpentiera*. Closer examination of the genera, however, dispels such an assumption.

Chamissoa is in many ways an artificial genus consisting of two quite distinct species. It is widely distributed from sea level to 2000m from northern Mexico through Central America into all countries of South America except Chile. It is also very common on most Caribbean Islands. The species favor disturbed sites at the edge of forests, on roadbanks, and on the margins of rivers and streams. The genus is delimited on the basis of the ovaries which develop into dehiscent fruit containing arillate seeds. In *Chamissoa altissima*, the aril is large, bivalved and completely encloses the seed. In *Chamissoa acuminata*, the aril is extremely small and easily overlooked. The former species usually develops into a robust woody vine that may become more than 20m tall and which branches profusely from the upper nodes. In the Dominican Republic it is commonly known as *pabellon de Rey* ("pavilion of the king"), because of the habit it often assumes; it drapes over and hangs down from other vegetation. *Chamissoa acuminata* rarely becomes more than a 1m suffrutescent plant. Both species possess the same basic unit inflorescence structure: a cymulose cluster of flowers in which the oldest flower is subtended by a true floral bract in addition to the two floral bracteoles. These cymulose clusters are usually arranged in panicles, but the nature of the inflorescence is variable. The young flowers arise in the axils of the bracteoles of the older flowers. This type of floral unit is basic for other inflorescences produced by genera such as *Indobanalia* and *Allmania* as well as *Chamissoa*. *Chamissoa altissima* is gynodioecious, whereas *C. acuminata* has bisexual flowers.

Charpentiera is a genus of six species, 5 of which are found in the Hawaiian Islands and the other is endemic to the Austral Islands (Sohmer, 1972). They are small to medium-sized trees. The species are easily recognizable for there are no others in these islands whose habit and appearance, particularly when in flower, are similar. The inflorescence is basically paniculoid and pendent with one to three orders of branching. The flowers are solitary and sessile. The basic cymulose units of flowers found in *Chamissoa* are never present here. All species of *Charpentiera* are gynodioecious. The fruit is indehiscent and the seed does not possess an aril. Table I summarizes the differences between *Chamissoa* and *Charpentiera*.

The resemblance between the two genera is quite superficial. The differences between them, not just in habit, but in the nature of the fruit, the aril and the structure of the inflorescence removes *Charpentiera* not only from *Chamissoa*, but from those genera, such as *Allmania* and *Indobanalia*, which share some of these features with *Chamissoa*. It seems advisable to look elsewhere for a possible progenitor or close relative of *Charpentiera*, if it still exists. Unfortunately, with the present state of knowledge concerning this group of Amaranthaceae, it is not possible to suggest a likely candidate at this time.

Table I. Features that differentiate the genera *Charpentiera* (A) and *Chamissoa* (B) (Amaranthaceae). (See text for discussion of characteristics.)

	Habit	Arrangement of flowers on infl.	Floral "sex"	Fruit	Aril
A	Small to medium-sized trees	flowers solitary on the inflorescence axes	All species gynodioecious	indehiscent	-
B	Suffrutescent; or woody vines	flowers in cymulose clusters, clusters are arranged on the inflorescence axes	one species gynodioecious; one species with bisexual flowers	dehiscent	+

Acknowledgments

I acknowledge the great amount of support given me by the University of Wisconsin-La Crosse such as a Teachers' Improvement Assignment in 1969-70 which allowed me to carry on the work with *Charpentiera* and grants-in-aid of research which permitted the work with *Chamissoa*. While in residence at the Smithsonian Institution as a Research Fellow during the academic year 1975-76, I found the spare time in which to write this paper. I thank Sara H. Sohmer and Jody Banks for their technical assistance.

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THE ELUSIVE KAUILA (*ALPHITONIA PONDEROSA*) OF O'AHU

John K. Obata

Whetted with the hope of finding Judd's botanical bonanza in Mākua Valley, five of us ventured into Mākua Valley on May 26, 1975. The path taken was down one of the precipitous ridges between Peacock Flat trail and the now abandoned former Tracking Station at the head of Kawaihāpai (or Kahanahāiki) Valley. This path was taken because Mākua Valley is an impact area for military ordinance activities and entry is forbidden. However, I was informed by an official forestry source that if we stayed inside the forestry fence, our entry would not violate any military directives. This information later proved to be incorrect.

The vegetation on the valley floor was very exotic, an occasional native plant here and there. Nothing rare. On fire-ravaged steeply sloped areas, there was considerable erosion. Where fires burned over level or gently sloped areas, molasses grass (*Melinis minutiflora*) took over completely. Then in the dry season the molasses grass became excellent fuel for future fires in a never ending cycle. However, in one area that had been burnt over many times by military exercises, two native species, 'iliahialo'e (*Santalum elipticum*) and 'ulei (*Osteomeles anthyllidifolia*), seemed to grow back from its root stock to compete with the overpowering molasses grass.

Getting into the native forest was a welcome relief. Here the dominant plant and about the only prominent plant was lama (*Diospyros*). In places the 'ōhi'a-lehua (*Metrosideros*) was quite common. A few a'ali'i (*Dodonaea*) and pūkiawe (*Styphelia*) broke the monotony of the many lama's. Only a handful of other native trees and shrubs were noticed. Alahe'e (*Canthium*), kōlealaunui (*Myrsine*), pāpalakēpau (*Pisonia*), hao (*Rauvolfia*), 'āla'a (*Planchonella*), kalia (*Elaeocarpus*), alani (*Pelea*), olopua (*Osmanthus*) to name most of them. In one area the understory was covered with about two acres of moa (*Psilotum*), an unusual sight. There were low shrubs like ko'oko'olau (*Bidens*) dotting the landscape. All in all botanizing was relatively uninteresting.

Along the vertical cliffs, I was told later, a *Brighamia* was previously sighted by another party. Much of the area was steep with a heavy cover of molasses grass. After meandering around several ridges, it was obvious that our hunt was fruitless.

Nearing the bottom of one of the steep ridges, one of my companions behind me called out "what's this tree?" With a casual glance backward, my reply was "*Colubrina* (kauila)." No one really stirred because this species had been seen elsewhere. Upon examining the tree more carefully, my companion shouted back "*Colubrina* my foot. It's *Alphitonia*." No one had seen this kauila on O'ahu in recent years. The ring of *Alphitonia* started a stampede to the tree. I had never seen a kauila (*Alphitonia*) in the wilds. For O'ahu, the two trees present were an exciting find.

Vouchers for this collection may be found at the Bishop Museum and the Harold H. Lyon Arboretum. We weren't the first to find *Alphitonia* on O'ahu. The Bishop Museum has the following vouchers: Judd, Aug. 5, 1926, Pōhākea Pass; Forbes, sterile specimen, Mokulē'ia, slopes of Ka'ala, Apr.-May 1912; Russ, complete voucher, Mākaha, March 1930; Lyon, complete voucher, Mākua, Sept. 27, 1932; Judd, voucher with fruits, Mākua, Feb. 9, 1928; Munroe, complete voucher, Diamond Head (1958-59), possibly from one of his plantings on the slopes of Diamond Head.

I'm still interested in finding Judd's little botanic bonanza. A lot of other people are interested in it too. I'm sure much of it is still there. The next time an army vehicle better escort me into the valley from the floor. The cliffs are too precipitous, a climb only for the demented. Those hardened hunters must still question our sanity. At least we found the long lost kauila at the 488m (1600ft) level. Those plants glistened in their beauty with their shiny black fruits daring others to come and pick them off their forbidden, steep habitat.

Editor's note. The following text of testimony was presented by Society Vice-President Sheila Conant before a hearing of the Senate Committee on Ecology, Environment and Recreation relative to the budget for the Department of Land and Natural Resources on February 12, 1976.

Thank you for the opportunity to present this testimony today. I am speaking in behalf of the Hawaii Audubon Society, the Hawaiian Botanical Society, but not as a representative of the University of Hawaii. We have some brief comments to make on specific items.

We support the proposed budget for the Natural Area Reserves System, but would like to suggest a slight amendment. At present the budget calls for the addition of one full-time position for a person to act in both administrative and scientific (as a biologist) capacities. We feel that instead of one position there should be two half-time positions, one for an administrator, and one for a biologist. Our reasoning behind this suggestion is this: it is extremely difficult to find an individual well-qualified to act in both capacities. In particular, biologists are not well-known for their ability as administrators, and it is nearly impossible to be an effective administrator while doing justice to one's duties as a biologist. We feel that one person doing both kinds of work is likely to excel at one type, at the expense of the other duties.

We are in strong support of the creation of a State Botanist position. We feel, however, that whomever is hired for this position should be housed with a good plant collection. This would be essential for the Botanist to carry out his work effectively. We are aware that there is a Federal Agency (i.e., the U. S. Forest Service) which has had staff members working at the Bishop Museum. The Museum has an excellent collection of the Hawaiian flora, and we urge that the arrangements be made for this new State position to be housed with the Museum. Should this turn out to be administratively impossible, we strongly suggest that the position be placed within either the State's Environmental Center or with the Department of Planning because we feel these are the most appropriate Departments for such a position. Of course, the Department of Botany at the University of Hawaii has a small collection of Hawaiian plants and could also be considered as a potential location for the new State Botanist.

We would also like to encourage enhancement of the Division of Fish and Game's Budget for enforcement activities. In fact, it seems appropriate to suggest the consideration of the establishment of a separate Division for Enforcement within the Department of Land and Natural Resources, in order to increase the effectiveness of this branch. Equipment (e.g., a boat for the island of Maui to patrol offshore islands) and personnel, as well as administrative independence might really help to solve some of the serious problems the enforcement branch must cope with.

Testimony on SB 2437 relating to conservation districts and use of land therein presented by Dr. Sheila Conant on March 1, 1976.

The Hawaiian Botanical Society strongly urges the passage of SB 2437, which would ammend chapter 183, as well as section 205-2, regarding the uses of lands in conservation districts.

Some uses (e.g., grazing, some agriculture) allowed in conservation district lands are actually damaging to its quality, especially as watershed. The annual review for conservation land use permits will provide frequent opportunities to monitor use carefully and thereby make prevention of destructive or degrading land practices more practicable. The bill also is quite clear in its intent to prevent degradation of conservation district lands.

We are in favor of increased and stringent enforcement of this law, and take this opportunity to urge you to pass SB 2912, which provides a measure for increased centralization and efficiency of law enforcement within the Department of Land and Natural Resources. We hope, thus, that policing of lands can all be accomplished in one division of the Department.

Of the three bills introduced in the legislature this year to ammend chapter 183 with respect to management of conservation lands, we find SB 2437 to be the most acceptable.

We would like to suggest that the measure in SB 2437 that automatically grants approval for permitted use of conservation land if the Board of Land and Natural Resources does not hold a public hearing within 180 days of permit application be changed. This provision would allow granting of permits by default, and could lead to misuse of conservation land and might encourage practices not in keeping with the spirit of this law. We urge you to make an appropriate change so that all permits must be granted after they are reviewed at a pulic hearing.

We congratulate the authors of this bill for the care they have taken to make this a solid piece of legislation espousing sound conservation practices.

Thank you for the opportunity to present this testimony.

Testimony presented at the U.S. Fish & Wildlife Service Public Hearing on Endangered Plants, July 14, 1976, by Ruth Gay, Conservation Committee.

The Hawaiian Botanical Society finds the proposals related to endangered and threatened plants offering constructive steps toward the conservation of a valuable biological resource.

The regulatory protection proposed in the June 7, *Federal Register* is the same as that provided in Sections 7 and 9.a.(2) of the Federal Endangered Species Act of 1973. The Hawaiian Botanical Society supports adoption of this proposal regarding export, import, commercial interstate transport and the alignment of Federal programs to the intent of the Act. This protection has been applied rationally to endangered birds and mammals in Hawaii, some species of which have wide-ranging distributions throughout forest, range, agriculture and military lands. Protection can be applied in a similar manner to endangered plants, and provide for continued improvement in the balance of multiple use of Hawaii's lands.

However, divergent opinions have been expressed concerning the future impact of this proposal. One opinion predicted that Hawaii's entire forest land or portion of agricultural land may be locked up as a critical habitat. Part of the divergence on this issue seemingly is due to an incomplete understanding of endangered species laws, regulations and programs. We recommend consideration of an intensive study workshop or series of workshops to be conducted in Hawaii in the near future for all persons involved or interested in the evolving endangered species programs. Through workshops, the base of understanding and communication can be widened; some differences of opinion can be resolved; and sound preparation can be made for future programs.

The second proposal under review is the list of endangered and threatened plant species published in the June 16, *Federal Register*. Listed species with known ranges in Hawaii were proposed, reviewed and revised by the most qualified botanists specializing in the Hawaiian flora. Decades of professional experience and innumerable hours of volunteer work are reflected in the selection of entries. The *Hawaiian Botanical Society Newsletter* of February, 1976 gives a chronological review of the development of the preliminary Smithsonian List; thus we are submitting, as part of our testimony, the entire article on endangered species as it appeared in Vol. 15, No. 1, pp. 7 - 21.

Our confidence in the professional competence of the scientists who provided input to this list leads us to support the proposal, in spite of the exclusion of threatened species. In favoring adoption, we believe that support and protection for endangered plants is long overdue. For the perpetuation of the most critical plant populations, prompt action is needed to allow the allocation of more adequate human resources toward the problems of endangered plants. Only through such action will the drive toward the extinction of these genetic reservoirs be diminished.

Unfortunately, the absence of threatened species on the proposed list may lead, by inference, to the incorrect conclusion that there are no threatened species. We suggest that threatened species, selected from preliminary lists submitted to the Office of Endangered Species, be proposed for addition at later dates. Due to their less critical status, as compared to endangered species, more time should be devoted to documenting evidence of the status of threatened species. However, to postpone the adoption of the endangered list for the period necessary to obtain more complete proof of status through generally voluntary efforts could further endanger the existence or recovery of numerous plant populations. Such delay would contravene the intent of the Endangered Species Act. Thus, the Hawaiian Botanical Society supports the adoption of the proposed endangered and threatened species list as soon as minor typographical errors are corrected. We have included below a short list of typographical corrections.

In closing, the Hawaiian Botanical Society urges that both proposals being reviewed here today be adopted without further delay.

Corrections of Endangered & Threatened Species List, *Federal Register*, 6/16/76

page 24527	The common name listed for *Rauvolfia remotiflora* should be changed to ha'o.
page 24538	*Alsinodendron*
page 24551	*Stenogyne sessilis* var. *lanaiensis*
page 24571	*Stenogyne kanehoana*

BOOK REVIEW

"WORLD GUIDE TO TROPICAL DRIFT SEEDS AND FRUITS" by C. R. Gunn & J. V. Dennis, IX & 240 pp., illus. Demeter Press Book, New York. $17.50.

Habitués of tropical and warm coasts of the World, if interested in Botany or Natural History, will welcome this outstanding mélange of compilation and research about plant flotsam and jetsam. It concerns propagules--both fruits and seeds--that have been carried by ocean currents from equatorial regions both North and South. When cast upon beaches they are conspicuous treasures for the beach comber. In general, the farther we search away from the Equator, the less specimens in kind and number shall we find. This is so because many have been stranded before drifting far distances, while many others have had time to become sufficiently waterlogged to sink to the bottom. Some seeds, such as the sea-heart (*Entada gigas*) have been found as far north as Spitzbergen; while others, such as the *goatsfoot morningglory (*Ipomoea pes-caprae* var. *emarginata*), have been found as far south as North Auckland, New Zealand. The common ipil (*Intsia bijuga*) has drifted as far as South Africa, its seeds having been found even on both sides of the Cape of Good Hope.

No explanation is given why little drift is carried from cold climates, both North and South, toward the Equator. We suspect three main reasons: a cold climate, with its brief growing season, produces a fraction as many floatable propagules as does a warm one; currents, both North and South, hardly scour such coasts; nor do such coasts possess major rivers to transport quantities of fruits and seeds into the oceans.

Beside 79 plates (dubbed "figures") of easily identifiable propagules executed by British artist Pamela J. Paradine, the book is illustrated further with 16 photographs. The interesting text, perhaps a bit lavish in waste of space, is the work of the famed American seed specialists and beach combers Charles R. Gunn and John V. Dennis. The introductory chapter of eight pages is followed by one equally as long concerning "History." This is replete with folklore and tales of human interest such as the making of snuff boxes. Chapter 3 involves "Transport Currents and Collecting Beaches" listed geographically. After "Collecting and Uses" the body of the work begins on page 58 with "Systematic Descriptions and Illustrations." Here a key for the identification of "disseminules" will aid the finder to identify his treasure if he has not long ago identified it by leafing through the fascinating drawings. Drawings of disseminules identified to the genera only and to the species total 114, while species mentioned and not illustrated approach 200. A few differences of opinion regarding binomials held by authors and us reviewers come to mind after making a spot check of the "Appendix." We prefer *Vachellia* (in place of *Acacia*) *farnesiana* for p. 209, *Myristica surinamensis* for p. 213, *Swietenia* for p. 215, *Tacca leonotopetaloides* and/or some unidentified species for p. 215, and *Messerschmidea* (in place of *Tournefortia*) *argentea* for p. 215. Indulging in a check of the probable completeness of the "Bibliography," we note that Degener, O., & I. Flotsam and Jetsam of Canton Atoll, South Pacific. Phytologia 28(4): 405-418. 1974., is conspicuous by its absence.

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* Inappropriately named by us and others as "soilbind morningglory," "seaside morningglory," and "railroadvine."

"World Guide to Tropical Drift Seeds and Fruits," published in 1976 and selling for $17.50, is highly recommended for residents of warm and tropical coasts. For the technical botanist, living anywhere at all and with $65 to spare, we recommend E. J. H. Corner's two volumes about "The Seeds of Dicotyledons," published by the Cambridge University Press the same year.

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BOOK REVIEW

"TREES OF PUERTO RICO AND THE VIRGIN ISLANDS" Volume 2 by Elbert L. Little, Roy O. Woodbury & Frank H. Wadsworth. United States Department of Agriculture Handbook No. 449.

This book is an outstanding bargain for botanists and foresters in tropical and subtropical regions of the New World. It augments Volume 1 which had appeared in July 1964 under the slightly different title of "Common Trees of Puerto Rico and the Virgin Islands," authored by Little and Wadsworth alone.

Volume 2, in a board cover measuring 3 x 8 x 10½ inches, binds over 1,000 pages of text and line drawings. Of the latter, five plates are of treeferns, one of a cycad, six of gymnosperms, ten of monocots such as palms, and over four hundred of dicotyledons. The illustrations are excellent for recognizing the species, especially for non-English speaking students. In a few cases the printing is unclear and, in some cases, the illustration on the page is small enough to have allowed the figuring of magnifications of flowers, fruits and seeds. Perhaps a second edition will include these.

The text up to page 42 explains such various subjects as botanical terms, statistical summary, forests and forestry, poisonous trees, character of latex, and keys to families. The body of the work then follows with family and generic descriptions, and full descriptions of species, almost all illustrated. Under the species descriptions are names used not only in Puerto Rico and the Virgin Islands but elsewhere, common names used in many regions and in many languages, and observations of particular importance to foresters.

This work by Little and coauthors would be a bargain even at twice the price. It is presently selling for US$ 13.45 by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

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RECENTLY COMPLETED THESES IN BOTANICAL SCIENCES AT UNIVERSITY OF HAWAI'I

SABOSKI, Eleanor M. 1976. Physiological Ecology of Hawaiian, Marine, Psammolittoral Diatoms. Ph.D. Thesis. Dr. S. M. Siegel, Chairman.

The distribution of marine diatoms within beach sand was studied on Kalapana Beach, Hawai'i and Kāhala Beach, O'ahu. The species communities were similar but there were fewer species at Kalapana, 46 versus 69 at Kāhala, and the number of cells was 2,000 times higher at Kāhala. The differences were related to high nutrient levels, low beach temperatures and more pore water at Kāhala, whereas at Kalapana the nutrient level was low, the wave activity was greater and there were relatively high mercury levels reflecting the volcanic source of the sand. The effects of mercury and tin on growth and morphology were studied. Common abnormalities in the frustule from such treatments were a reduction in length relative to width, fusion of the carinal dots and a reduction of carinal dots per frustule. Changes in cell ultrastructure were also noted. The effective levels of tin and mercury were in the range known in polluted natural waters and the indicator value of diatoms for monitoring metal pollution was demonstrated.

MURCH, Randall S. 1976. Studies Involving the Phytotoxin of *Pseudomonas glycinea*, a Pathogen of Soybean. M.S. Thesis. Dr. S. S. Patil, Chairman.

The study relates to toxins released by the *Pseudomonas* bacteria which induce chlorosis. Toxins of phytopathogenic Pseudomonads have been separated into two groups based on their physical and chemical properties. However, it was not known whether the toxins within the bean and soybean infecting group were different.

The toxins from *Pseudomonas glycinea* and *P. phaseolicola* were similar but not identical as might be suggested on the basis of their belonging to the same group. However, it was suggested that the toxin from *P. glycinea* may contain a mixture of closely related substances which might account for the lack of similarity between the two toxins.

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Contents

VOLUME 15 NUMBER 4/5 OCTOBER/DECEMBER 1976

ECOLOGY OF THE DRYLAND FOREST AT KĀNEPUʻU, ISLAND OF LĀNAʻI
by Glen E. Spence and Steven L. Montgomery . . . 62

PUUKOHOLA HEIAU NATIONAL HISTORIC SITE PLANT SURVEY
by Lisa Croft, Don E. Hemmes and James D. Macneil 81

BRIEF REPORTS

SOCIETY BUSINESS 94

*

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ECOLOGY OF THE DRYLAND FOREST AT KĀNEPU'U, ISLAND OF LĀNA'I

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The Kānepu'u dry forest is located in the central northwest section of the Island of Lāna'i, the sixth largest of the Hawaiian Chain with an area of 141 square miles. Lāna'i is a single volcanic dome; its highest point, Lāna'ihale, rises 3,370 feet above sea level. Lāna'i volcano is believed to have been extinct longer than any volcano found among the major islands. There are two partially-filled caldera located on the central plateau where pineapple fields are presently situated. The mountainous area of Lāna'ihale is located on the eastern side of the island. To the north, south, and west of the central plateau, mostly below 1000 feet elevation, the land slopes steeply to the ocean, eroded in many places into deep rocky gulches.

In this study, the term "Kānepu'u" refers to 275 acres within a planted *Eucalyptus* windbreak (Fig. 1). The region referred to as "the Kānepu'u area" is northwest Lāna'i within the mauka lands of Kā'a, Paoma'i, and Mahana ahupua'a, in which scattered stands of indigenous dry forest vegetation occur. Because of the emphasis George Munro placed on the vegetation within the windbreak, our study was concentrated there. We did not ignore the additional examples of native vegetation outside the windbreak, which were also reconnoitered. We believe these isolated stands should not be forgotten as possible conservation zones. They are smaller and more restricted in species composition, but in at least three separate patches, regeneration of species not reproducing within the windbreak was found. The 'aiea (*Nothocestrum*), 'ohe kukuluāe'o (*Reynoldsia*), and the rare nānū (*Gardenia*) were observed in both seedling and sapling stages within small stands to the northeast of the windbreak. The similarities between the study area and these peripheral stands allows us to expand our general conclusions to these areas.

The slight hill designated on topographic maps as Kānepu'u is located approximately one-half mile to the south of the windbreak; its elevation is 1799 feet. The Lāna'i City to Kā'a jeep road enters the windbreak from the southeast and divides, one branch continuing to the northwest (Awalua jeep trail) the other to the north (Lapaiki jeep trail).

MUNRO'S LAND STEWARDSHIP

Kānepu'u benefited from the interest taken in the native flora by George C. Munro, an amateur ornithologist and botanist who served as manager for the now defunct Lāna'i Ranch in the early part of this century.

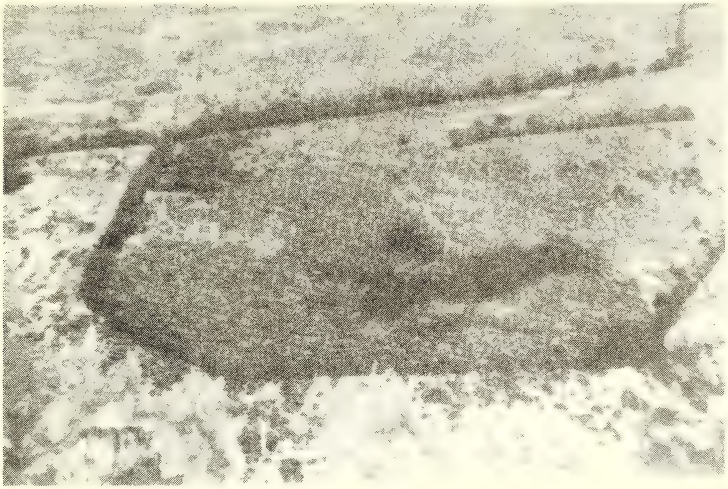


Figure 1. An aerial view of the Kānepu'u study site.

Munro's unpublished notes provided a checklist of native plants known to be present in the area from 1918 to 1930. His ambition was to preserve as much of the native flora as possible within Kānepu'u. He planted an extensive windbreak of *Eucalyptus* around the forest with the intention of protecting it from intruding erosion. He gathered seeds from native species in other areas and spread these within the boundaries of the windbreak. Munro was successful in fencing the forest in 1918 to keep out unwanted sheep and cattle, but the fence was removed in 1935 after he had retired. The same year the fence was removed, Fosberg studied the area and was impressed with this native dry forest, which he felt might even be considered "an anachronism." He stated that it is apparently the sole remaining good example of the type of forest which must have covered great areas in the lowlands of the Hawaiian group.that is still in good condition (Fosberg 1936).

After revisiting Lanai's xerophytic forest, Munro (1952) urged that conservationists follow up on a Hawaiian Botanical Society letter to the owner, Castle and Cooke, Inc. He recommended that the area be protected from animals and kept as a "living museum." Munro noted that dark-rumped petrels (now an endangered species) once nested in burrows near Kānepu'u, but these seabirds now are seen on Lāna'i only near the summit. We found egg shell fragments of a large, unknown bird that were exposed by wind erosion from under two feet of old loess deposits located above Kahua Gulch.

Nearly all of George Munro's actions on Lāna'i displayed a deep concern and understanding of the island's intrinsic natural values, and he well deserved being referred to as Hawaii's most dedicated conservationist (Lamoureux 1963).

GENERAL ENVIRONMENTAL CONDITIONS

Vegetation is said to reflect the climatic conditions of an area. At Kānepu'u, wind, temperature, and rainfall have had the most obvious effects.

Wind. The main Kānepu'u forest lies on a plateau exposed to the predominantly northeast tradewinds. The channel between Moloka'i and West Maui serves as a venturi through which tradewinds are funneled and reach northwest Lāna'i with greater velocity. We have located no measurements of wind speeds there, but Daniels (1973) notes that winds moving over crests, around headlands, and through saddles become stronger.

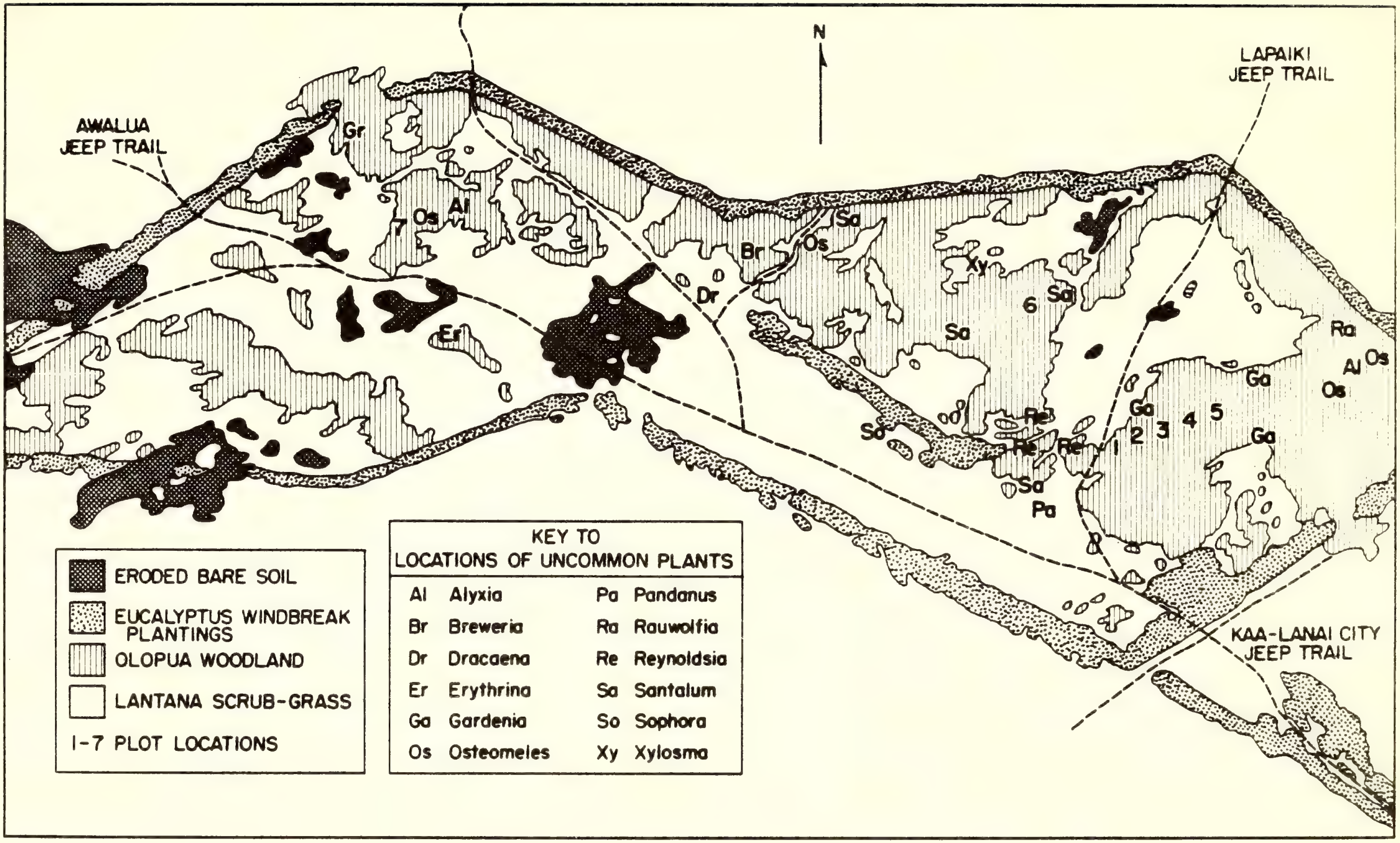
The appearance of the vegetation is comparable in some ways to the ridge vegetation found on the other islands. Structurally, the native trees are of low stature, with none reaching over six meters. The canopies appear rounded and lean toward the southwest, particularly those on the northeast border. Their exposed sides bear little foliage, and trunks sometimes lean as much as forty-five degrees.

The wind has not only affected the structural development of the forest but, coupled with the removal of the vegetation by introduced mammals, Lāna'i is now a show-place for wind erosion. Some individuals surmise that the entire Paoma'i-Kā'a-Mahana area was once covered with a native forest much like that still found at Kānepu'u. This conjecture was perhaps true above a certain elevation, but if so, after the introduction of cattle and sheep during the nineteenth century, much of this forest disappeared. Early whaling ships reported seeing large dust clouds from the island. Fosberg (1936) compared one broad, red, eroded gulch just north of Kānepu'u to Colorado's Garden of the Gods, and the name is often applied to this site.

One of Munro's principal goals was to stop this erosion. He planted windbreaks and experimented with various grasses to cover large eroded sections. The removal of cattle, as well as sheep, was begun by Munro during his last years as ranch manager. In the early 50's, cattle and domestic sheep were removed as ranching became less profitable. It should be remembered however, that after the removal of the fence in 1935, cattle were allowed to run within the area until 1950. Soon the main industry shifted to the production of pineapple, which appears to be uneconomical in the Kānepu'u area.

Wind erosion is still a problem on Lāna'i. In recent years its effects have been retarded, but large areas remain barren of vegetation. Gullies continue to lose soil and become more precipitous, eating away at the edges of the plateau. Even within the Kānepu'u windbreak, sections of exposed soil remain (Figs. 1 and 2).

Precipitation. The low rainfall on Lāna'i has always influenced the island's environment significantly. Lāna'i lies partially in the rain shadow of Moloka'i and West Maui. Most moisture carried by the northeast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ERODED BARE SOIL
EUCALYPTUS WINDBREAK PLANTINGS
OLOPUA WOODLAND
LANTANA SCRUB-GRASS
1-7 PLOT LOCATIONS
KEY TO LOCATIONS OF UNCOMMON PLANTS
Al Alyxia
Br Breweria
Dr Dracaena
Er Erythrina
Ga Gardenia
Os Osteomeles
Pa Pandanus
Ra Rauwolfia
Re Reynoldsia
Sa Santalum
So Sophora
Xy Xylosma

Figure 2. Vegetation map of the Kānepu'u Study Site showing location of study plots.

trades is intercepted before it reaches the island. Only during the months of December through February, when "kona storms" predominate, does Lāna'i experience heavy rains.

Rainfall data over a 24 year period, coupled with available temperature readings from the Lāna'i Airport, indicate that Kānepu'u experiences eight months of drought conditions (Fig. 3).

Soil. The soil found in the Kānepu'u area belongs to the great soil group Humic Ferruginous Latosol. The soil in this group is highly acidic and fertility is usually extremely low. Soluble plant nutrients are missing because of leaching in this well-drained soil. Heavy concentrations of oxides of iron and titanium occur in the surface layer (Baker, et al. 1967). The depth of the soil is greater than 30 inches. Eroded areas have lost 25 to 50 percent of their original surface soils, and large boulders are left scattered throughout. No extensive, rocky areas were encountered inside the Kānepu'u windbreak.

Topography. The main study area is level and free of gullies or stream beds, but contains small areas of barren subsoil. Just to the north and east of the windbreak the terrain descends rather abruptly toward the ocean, dropping approximately 500 vertical feet per horizontal mile. These areas have been exposed to harsh erosional factors and contain extensive gullies, barren sections, and a dozen or so forested patches.

ZONATION

Over the years various schemes have been used to describe vegetation zones for the Hawaiian Islands. Most of these have been artificial, based on a single or a few factors grouped together; i.e. soil type, rainfall, dominant or indicator species, agricultural use, etc. The most ideal system would be one based on the ecosystem concept, one which takes into account all available factors and groups vegetation into their potential climax. However, the realization of the climax condition is sometimes difficult to ascertain, particularly in Hawai'i, where plant associations are constantly being disrupted by the introduction of new species and other man-made disturbances. Though not a major concern for this study, a look at two zonation schemes does point to the uniqueness of the Kānepu'u forest.

Because of the rapid turnover of vegetation types, particularly in the lowlands, recent works dealing with vegetation zones have concentrated on exotic plant communities, these being dominant. Only at higher elevations where human influence has been mimimal, or in inaccessible areas of the lowlands, are forests still dominated by native species.

Rock's (1913) treatment of vegetation zones ("botanical regions") is perhaps the oldest and yet most applicable to native Hawaiian vegetation. His regions are based on climate conditions (wind, rainfall, etc.) and topographic changes caused by lava flows. Rock gives no systematic expla-

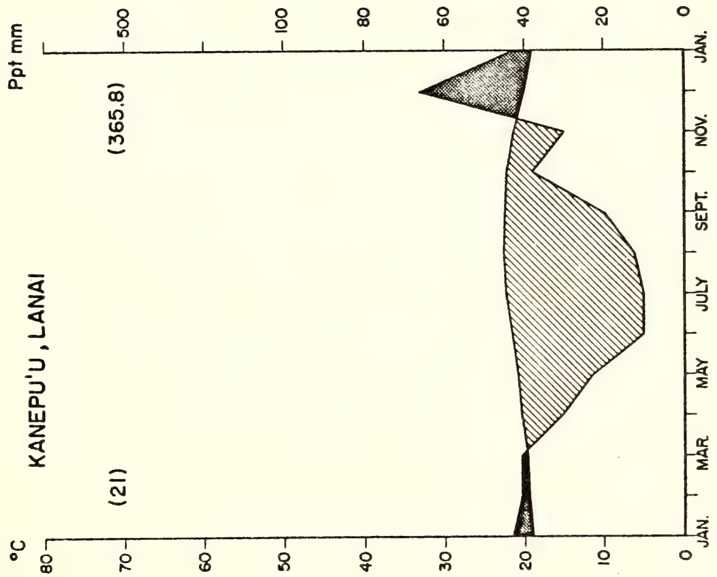

Figure 3. Climate diagram of Kānepu'u Study Site.

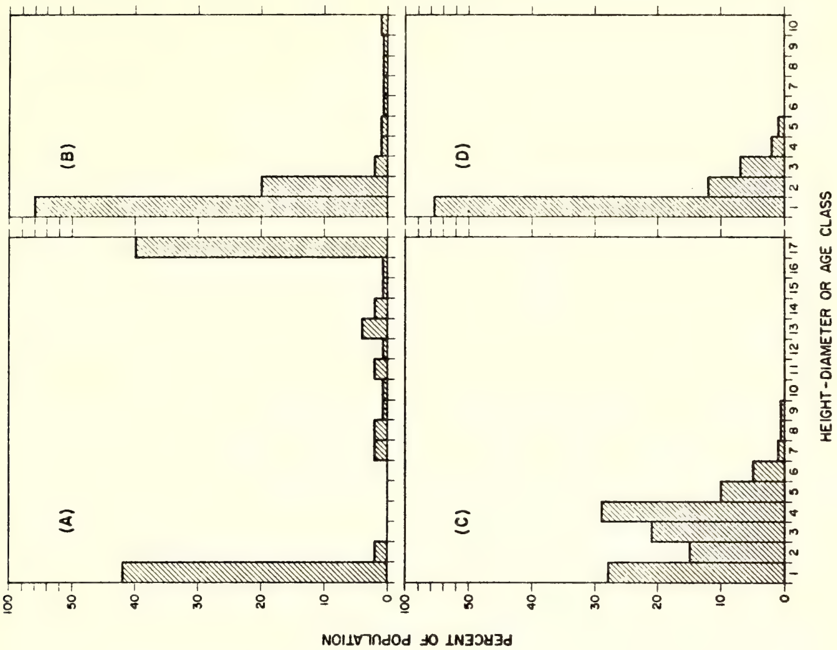

Figure 4. Population size class diagrams of A) *Osmanthus*, B) *Diospyros*, C) *Lantana*, D) *Schinus* at Kānepu'u.

nation (data) for his classification; instead, he uses the species composition to indicate forest zones, or states to which zone a particular species belongs after his species descriptions. He places the Kānepu'u area into his Lowland Dry Region. No other forest falling into this zone is structurally the same or dominated by olopua (*Osmanthus*).

The zonation scheme proposed by Ripperton and Hosaka (1942) is the one employed by most workers. Their maps place the Kānepu'u area in zone "B", which evidently is based mainly on rainfall. The vegetation described for zone "B" does not reflect that actually found in the Kānepu'u forest. This is understandable since their scheme is geared toward the vegetation which is most common to a particular zone. Because Kānepu'u is dominated by native Hawaiian plants, it is not described in the scheme of Ripperton and Hosaka.

Because of the low rainfall and the number of months of drought which the Kānepu'u area experiences (Fig. 3), it falls into what most workers refer to as the dry zone. This zone is one of the most disturbed because of its use by man. Since Rock, the dryland forest has been known as the richest botanical region in Hawai'i in terms of tree species.

VEGETATION DESCRIPTION

Vegetation within the Kānepu'u windbreak can be divided into two structural types. These are defined as: (1) *Closed scrubgrass*; composed of woody plants less than two meters tall (nanophanerophytes) sometimes growing close together over a dense cover of herbs and grasses; and, (2) *Woodland*; composed of woody plants two to eight meters tall (microphanerophytes) with interlocking crowns and sparse ground cover.

Scrub-grass. The first of these structural types is not altogether homogeneous in species composition and could be further subdivided into distinctive plant communities. One transect line, with 15 one-meter square plots placed at three-meter intervals and running through an area believed to be representative of this structural type, was used for the delineation of the dominant components. The following data was taken in each plot: (1) cover for each species in all synusia (layers) using the Braun-Blanquet rating scales; (2) height for all woody species; (3) weight by cropping at ground level for all herbs and grasses.

A two-way table analysis (Table 1) of the scrub-grass vegetation type demonstrates that there are two distinctive plant associations within the area. The first is a *Lantana-Melinis* association within which two species groups can be found; a *Salvia-Calamagrostis* grouping, and a *Cynodon-Cassia* grouping. The other association in the scrub-grass vegetation type is the *Paspalum* association.

Woodland. The second structural type is technically referred to as woodland and not a true forest because of its low height. The crowns of the dominant native trees form a dense interlocking canopy allowing little

Table 1. Two-way Analysis Table of Fifteen Plots in the Scrub-grass Community.

Species	Species	Plot Number														
	Group	8	7	3	4	1	11	12	13	5	14	2	6	15	9	10
Lantana camara	I			+	3	3	4	2	1	3	5	3		+	r	
Melinis minutiflora	I					4	3	3	5		+					
Paspalum orbiculare	I	+	1	2	+	2	1	+				1	1			
Sida fallax	I			1	1	2		+		+	+		+			
Plantago lanceolata	I	1	+	1	+	1				3		+	+			
Salvia coccinea	II	+	3	+	1	+	+				+	+	+			
Calamagrostis hillebrandii	II	+	3	3	3		+						+			
Cynodon dactylon	III					r						2	1			
Cassia leschenaultiana	III			r		r						2	1			
Paspalum sp.	IV						1	1	1				3	5	5	5
Bidens pilosa	V									1						
Lycurus phleoides	V	1								1						
Pteridium aquilinum	V								+		+			+		
Oxalis sp.	V	r								r			+			
Emilia sonchifolia	VI	+	+	r	+	+				+						
Cocculus ferrandianus	VI	+	1	+	+	+	+	+		+	+	+	+		+	+

light to penetrate to the forest floor. Under these conditions, the normally aggressive *Lantana* is reduced in vigor. The sparse cover of the forest floor is dominated by the exotic mint lili-lehua (*Salvia*); seedlings of the native lama (*Diospyros*) are abundant and only where the presence of dead trees allows light to penetrate does *Lantana* become common. Seedlings of Christmas berry (*Schinus*), another aggressive exotic, are found scattered throughout, an indication of an early stage of establishment in Kānepu'u.

A detailed synecological study which included setting up seven study plots (Fig. 2) was carried out. Plots one through five (plots 1-4 being 150 m^2 and plot 5 at 200 m^2) were set up along a transect line in a geographically continuous woodland type (see Fig. 2). The community was given the name "olopua woodland" after its dominant element olopua (*Osmanthus sandwicensis*). Because of the discontinuity of the woodland structure within the study area, two 200 square meter plots were set up in geographically separate but structurally similar areas, to check on the similarity of the vegetation, if any. The two localities were very similar when analyzed (Table 2). Within each plot the following data was

Table 2. Two-way Analysis Table of Seven Plots in the Woodland Area.

Species	Plot Number						
	1	2	3	4	5	6	7
Osmanthus sandwicensis	5	4	4	4	3	4	4
Salvia coccinea	2	4	2	3	1	2	1
Diospyros sandwichensis	2	2	+	2	2	2	2
Lantana camara	1	1	2	1	2	2	1
Oplismenus hirtellus	1	1	+	2	+	+	+
Schinus terebinthifolius	+	+	+	+	+	+	+
Cocculus ferrandianus	+	1	1		+	+	+
Physalis peruviana	+		r	r	+	2	+
Passiflora edulis	+	+	+		+	+	+
Sida fallax	r	+	r	r		+	
Oxalis corniculata			+	r	+	+	
Paspalum orbiculare			+		+	+	
Cassia leschenaultiana	r	r	+		r		
Leucaena leucocephala				r		+	+
Psilotum nudum	r		+		r		
Myoporum sandwicensis		r		+			r
Abutilon molle				+	+		
Verbena littoralis					+	+	
Ipomoea cairica	r		+				
Ipomoea indica				+			
Bobea sandwicensis						+	
Solanum sodomeum						+	
Nothocestrum latifolia					r		
Nesoluma polynesicum							r
Canthium odoratum							r
Cirsium vulgare							r

taken: (1) cover for each species in all synusia using the Braun-Blanquet rating scale; (2) diameter at ground level for all woody species above two meters; and, (3) the size class for all woody species below two meters in height.

Perhaps the most unique aspect of the Kānepu'u forest is its dominant tree, the olopua (*Osmanthus*). This forest type is represented in only a few other places in the islands; near Pu'u Oili at the western edge of Auahi, Maui and at Pu'u Wa'awa'a in Kona. The rounded crowns and branching trunks exhibit intriguing patterns both from above and below. This habit results from the way in which olopua maintains itself as the dominant element of the forest. Although many small seedlings were seen, there were no saplings (Fig. 4). Ordinarily, this apparent lack of successful saplings would indicate eventual local extinction, however, as the older main trunks die back, new trunks sprout from the base. As a result, some trees were found to have upwards of 30 trunks.

The second very abundant native tree is the lama (*Diospyros*). This species is the only one showing a size class distribution that would indicate the continuing replacement of the species (Fig. 4). If the olopua were to die out, it seems quite possible that the lama would become the dominant element of the forest. Other native and for the most part rare trees include alahe'e (*Canthium*), kōlea (*Myrsine*), 'aiea (*Nothocestrum*), ohe kukuluāe'o (*Reynoldsia*), ahakea (*Bobea*), nānū (*Gardenia*), naio (*Myoporum*), keahi (*Nesoluma*), ala'a (*Planchonella*), hao (*Rauwolfia*), iliahi (*Santalum*), and maua (*Xylosma*).

The analysis of density and dominance data shows that olopua dominates the upper canopy (two to eight meters) of the forest with lama (*Diospyros ferrea*) being the second most common species (Table 2). The exotic lantana becomes dominant in this layer where dead trees have left an opening. Another exotic species, the Christmas berry (*Schinus terebinthifolius*), is in the early process of invading the overhead canopy (Fig. 4, Table 2). It appears to grow well in the shade and exhibits an exceptional ability to compete with other tree species. These exotics are usually large shrubs, but within a low stature forest such as Kānepu'u, they reach heights comparable to the upper canopy limits. Other native tree species which were encountered within the plots but which play subordinate roles were: naio (*Myoporum sandwicense*), alahe'e (*Canthium odoratum*), keahi (*Nesoluma polynesicum*), 'aiea (*Nothocestrum latifolium*), and ahakea (*Bobea sandwicensis*).

The shrub layer (25 cm to 2 m) is dominated by either *Salvia coccinea* or *Lantana camara*. Saplings of lama are quite common as well as Christmas berry. Subordinate species in this layer include *Physalis peruviana*, *Passiflora edulis* (this vine sometimes reaching into the upper canopy), *Sida fallax*, and *Abutilon molle*.

The herb layer is dominated by seedlings of lama and lantana with other small herbaceous plants being subordinate (Table 2). The hue hue is found throughout this layer.

Munro reported 55 native species, 16 being "sown or planted", with seven germinating and reaching maturity. Some flowered but no seedlings were seen. A total of fifteen species have disappeared from the area (Table 3), and another seventeen are presently disappearing (those species not showing both seedling and sapling stages). We noted seven relict species establishing germinants, but a later visit indicated these had been browsed by deer or had died back for unknown reasons. (A relict is defined as a species within a plant community representative of an earlier stage of development or of a different set of environmental conditions.) The conditions have changed. Deer, rats, insects and diseases are destroying seeds and seedlings. It appears that most native species are producing seeds and fourteen native species are maintaining themselves, either by establishing seedling and sapling stages or by vegetative means.

A publication of the Harold L. Lyon Arboretum (Hirano and Nagata, 1971) dealing with success in the propagation of native plants shows that,

Table 3. Native plants recorded by Munro from Kānepu'u before 1934 but not present in 1971.

Scientific Name	Common Name
Abutilon eremitopetalum Caum	ma'o, hidden petaled abutilon
A. menziesii Seem.	ko'oloa'ula
Antidesma platyphyllum Mann	hame
Boerhavia diffusa L.	alena
Canavalia lanaiensis Deg. & Deg.	Lāna'i jackbean,'awikiwiki
Cassia gaudichaudii H. & A.	uhiuhi
Euphorbia celastroides Boiss. in A. DC.	'akoko
Haplostachys munroi Forbes	none known
Hibiscus brackenridgei Gray	ma'ohauhele
Ipomoea tuboides Deg. & van Ooststr.	Hawaiian moon flower
Kokia drynarioides (Seem.) Lewt.	koki'o
Nototrichium sandwicense (Gray in Mann) Hbd.	kulu'ī
Pittosporum hosmeri Rock	'a'awa hua kukui
Sicyos hispidus Hbd.	none known
Vigna sandwicensis Gray	none known

of the 55 native species listed in Table 4, forty have been successfully propagated. Germination probably occurs in the wild, but in the present environmental situation, conditions may no longer be favorable. However, a program of controlled propagation, like that of the Lyon Arboretum, could be included as part of the Lāna'i Company's reforestation program or attempted by the State Division of Forestry. After successful germination, certain seedlings could be transplanted to a selected, and hopefully, fenced area within Kānepu'u.

What is to become of Kānepu'u? It is impossible for this unique forest to be restored to its original condition. The introduction of exotic plants and animals since the arrival of Captain Cook has changed the local ecosystem irreversibly. There are three resource management activities which should be implemented to allow the Kānepu'u woodlands to retain their unique structure and hopefully revert to a condition closer to the original status.

First, fires should be suppressed. There is no evidence to suggest that fire played any role in the maintenance of this ecosystem. If fires did occur they were probably originated by lightning in which case they would have been infrequent and small in size. The activities of man in the woodland or adjacent regions probably account for the recent fire in the spring of 1974.

Secondly, axis deer are having a dramatic impact on such a woodland. Several steps could be taken to limit the activity of axis deer in the

Table 4. Checklist of Native and Exotic Plants at Kānepu'u, Lāna'i. 1976. The abbreviations for origin are: E = Endemic, I = Indigenous and X = Exotic. The classification of status is: Rare = solitary or few with small cover, Common = few plants with small but obvious cover, Frequent = numerous and cover up to 25 percent, and Abundant = generally large numbers and cover over 25 percent.

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
Ferns and Fern Allies			
PSILOTACEAE			
Psilotum nudum (L.) Beauv.	Moa, Psilotum	Rare	I
DENNSTAEDTIACEAE			
Pteridium aquilinum var. *decompositum* (Gaud.) Tryon	Kīlau, bracken	Rare	E
Gymnosperms			
ARAUCARIACEAE			
Araucaria heterophylla (Salisb.) Franco	Norfolk Island Pine	Rare	X
Monocotyledons			
PANDANACEAE			
Pandanus odoratissimus L.	Hala, Pandanus	Very rare	I
POACEAE (Gramineae)			
Cenchrus echinatus L.	'ume'alu, Common Sandbur	Rare	X
Cynodon dactylon (L.) Pers.	Mānienie, Bermuda grass	Abundant	X
Melinis minutiflora Beauv.	Molassesgrass	Abundant	X
Oplismenus compositus (L.) Beauv.		Frequent	X

Table 4. Checklist of Native and Exotic Plants at Kānepu'u, Lāna'i. 1976. The abbreviations for origin are: E = Endemic, I = Indigenous and X = Exotic. The classification of status is: Rare = solitary or few with small cover, Common = few plants with small but obvious cover, Frequent = numerous and cover up to 25 percent, and Abundant = generally large numbers and cover over 25 percent.

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
Ferns and Fern Allies			
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Psilotum nudum (L.) Beauv.	Moa, Psilotum	Rare	I
DENNSTAEDTIACEAE			
Pteridium aquilinum var. *decompositum* (Gaud.) Tryon	Kīlau, bracken	Rare	E
Gymnosperms			
ARAUCARIACEAE			
Araucaria heterophylla (Salisb.) Franco	Norfolk Island Pine	Rare	X
Monocotyledons			
PANDANACEAE			
Pandanus odoratissimus L.	Hala, Pandanus	Very rare	I
POACEAE (Gramineae)			
Cenchrus echinatus L.	'ume'alu, Common Sandbur	Rare	X
Cynodon dactylon (L.) Pers.	Mānienie, Bermuda grass	Abundant	X
Melinis minutiflora Beauv.	Molassesgrass	Abundant	X
Oplismenus compositus (L.) Beauv.		Frequent	X

Table 4 (Continued).

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
POACEAE (Gramineae) (continued)			
Panicum maximum Jacq.	Guinea grass	Abundant	X
Paspalum orbiculare Forst. f.	Mau'ulaiki, Rice grass	Frequent	X
Rhynchelytrum repens (Willd.) C. E. Hubb.	Natal redtop	Frequent	X
Setaria verticillata (L.) Beauv.	Bristly foxtail	Rare	X
COMMELINACEAE			
Commelina diffusa Burm. f.	Honohono	Rare	X
LILIACEAE			
Cordyline terminalis (L.) Kunth	Ti, ki	Rare	X
Pleomele aurea (H. Mann) N. E. Br.	Halapepe, Golden Dracaena	Rare	E
AMARYLLIDACEAE			
Agave americana L.	Malina, Century plant	Frequent	X
Dicotyledons			
CASUARINACEAE			
Casuarina sp.		Rare	X
PROTEACEAE			
Grevillea robusta A. Cunn. in R. Br.	Silk oak	Rare	X
SANTALACEAE			
Santalum lanaiense (Rock) Rock		Rare	E

MENISPERMACEAE			
Cocculus virgatus Hbd.		Frequent	E
LAURACEAE			
Cassytha filiformis L.	Kaunoa'oa	Rare	I
ROSACEAE			
Osteomeles anthyllidifolia Lindl.	U'ulei, Hawaiian hawthorn	Rare	E
LEGUMINOSAE			
Acacia farnesiana (L.) Willd.	Kolū	Rare	X
Caesalpinia sp.		Rare	X
Cassia leschenaultiana DC.	Lauki, Cowpea	Frequent	X
Desmanthus virgatus (L.) Willd.	Virgate mimosa	Frequent	X
Desmodium sp.		Frequent	X
Erythrina sandwicensis Deg.	Wiliwili	Rare	E
Indigofera suffruticosa Mill.	'inikō, Indigo	Rare	X
Leucaena leucocephala (Lam.) de Wit	Koa haole	Common	X
Sophora chrysophylla var. *lanaiensis* Chock	Māmane	Very rare	E
OXALIDACEAE			
Oxalis corniculata L.f.	'ihi, Lady's sorrel	Frequent	X
O. martiana Zucc.	'ihi pehu, Pink wood sorrel	Rare	X
EUPHORBIACEAE			
Euphorbia sp.		Rare	
Ricinus communis L.	Castor bean	Rare	X
ANACARDIACEAE			
Schinus terebinthifolius Raddi	Naniohilo, Christmas berry	Frequent	X
SAPINDACEAE			
Dodonaea eriocarpa Sm.	'A'ali'i	Rare	E

Table 4 (Continued).

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
POACEAE (Gramineae) (continued)			
Panicum maximum Jacq.	Guinea grass	Abundant	X
Paspalum orbiculare Forst. f.	Mau'ulaiki, Rice grass	Frequent	X
Rhynchelytrum repens (Willd.) C. E. Hubb.	Natal redtop	Frequent	X
Setaria verticillata (L.) Beauv.	Bristly foxtail	Rare	X
COMMELINACEAE			
Commelina diffusa Burm. f.	Honohono	Rare	X
LILIACEAE			
Cordyline terminalis (L.) Kunth	Ti, ki	Rare	X
Pleomele aurea (H. Mann) N. E. Br.	Halapepe, Golden Dracaena	Rare	E
AMARYLLIDACEAE			
Agave americana L.	Malina, Century plant	Frequent	X
Dicotyledons			
CASUARINACEAE			
Casuarina sp.		Rare	X
PROTEACEAE			
Grevillea robusta A. Cunn. in R. Br.	Silk oak	Rare	X
SANTALACEAE			
Santalum lanaiense (Rock) Rock		Rare	E
MENISPERMACEAE			
Cocculus virgatus Hbd.		Frequent	E
LAURACEAE			
Cassytha filiformis L.	Kaunoa'oa	Rare	I
ROSACEAE			
Osteomeles anthyllidifolia Lindl.	U'ulei, Hawaiian hawthorn	Rare	E
LEGUMINOSAE			
Acacia farnesiana (L.) Willd.	Kolū	Rare	X
Caesalpinia sp.		Rare	X
Cassia leschenaultiana DC.	Lauki, Cowpea	Frequent	X
Desmanthus virgatus (L.) Willd.	Virgate mimosa	Frequent	X
Desmodium sp.		Frequent	X
Erythrina sandwicensis Deg.	Wiliwili	Rare	E
Indigofera suffruticosa Mill.	'inikō, Indigo	Rare	X
Leucaena leucocephala (Lam.) de Wit	Koa haole	Common	X
Sophora chrysophylla var. *lanaiensis* Chock	Māmane	Very rare	E
OXALIDACEAE			
Oxalis corniculata L.f.	'ihi, Lady's sorrel	Frequent	X
O. martiana Zucc.	'ihi pehu, Pink wood sorrel	Rare	X
EUPHORBIACEAE			
Euphorbia sp.		Rare	
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ANACARDIACEAE			
Schinus terebinthifolius Raddi	Naniohilo, Christmas berry	Frequent	X
SAPINDACEAE			
Dodonaea eriocarpa Sm.	'A'ali'i	Rare	E

Table 4 (Continued).

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
MALVACEAE			
Abutilon grandifolium (Willd.) Sweet	Ma'o, Hairy abutilon	Frequent	X
Malvastrum coromandelianum (L.) Garcke	Hauuoi, False mallow	Common	X
Sida cordifolia L.	Pantropic Sida	Frequent	I
S. spinosa L.	Prickly Sida	Common	X
STERCULIACEAE			
Waltheria americana L.	Hi'aloa	Common	I
FLACOURTIACEAE			
Xylosma hawaiiense Seem.		Rare	E
PASSIFLORACEAE			
Passiflora edulis Sims	Lilikoi	Common	X
CACTACEAE			
Opuntia megacantha Salm-Dyck	Panini, Prickly pear	Rare	X
MYRTACEAE			
Eucalyptus robusta Sm.	Swamp mahogany	Abundant	X
Psidium guajava L.	Guava	Common	X
ARALIACEAE			
Reynoldsia venusta var. *lanaiensis* Sherff	'ohe kukuluāe'o	Rare	E
APIACEAE (Umbelliferae)			
Foeniculum vulgare Mill.	Sweet fennel	Abundant	X

EPACRIDACEAE			
Styphelia tameiameiae (Cham.) F. Muell.	Pūkiawe	Rare	E
MYRSINACEAE			
Myrsine lanaiensis Hbd.	Kolea	Common	E
PRIMULACEAE			
Anagallis arvensis L.	Scarlet Pimpernel	Rare	X
SAPOTACEAE			
Nesoluma polynesicum (Hbd.) Baill.	Keahi	Rare	E
Planchonella spathulata (Hbd.) Pierre		Rare	E
EBENACEAE			
Diospyros ferrea var. *degeneri* f. *lanaiensis* Fosb.	Lama	Abundant	E
OLEACEAE			
Osmanthus sandwicensis (Gray) Knobl.	Olopua	Abundant	E
APOCYNACEAE			
Alyxia olivaeformis Gaud.	Maile	Rare	E
Rauvolfia molokaiensis Sherff	Hao	Rare	E
Thevetia peruviana (Pers.) K. Schum.	Be-still tree, yellow oleander	Common	X
CONVOLVULACEAE			
Bonamia menziesii Gray		Rare	E
Ipomoea cairica (L.) Sweet	Koali	Frequent	I
I. congesta R. Br.	Koali'awania, Morning glory	Frequent	I
Jacquemontia sandwicensis Gray	Pa'uohi'iāka	Rare	E

Table 4 (Continued).

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
MALVACEAE			
Abutilon grandifolium (Willd.) Sweet	Ma'o, Hairy abutilon	Frequent	X
Malvastrum coromandelianum (L.) Garcke	Hauuoi, False mallow	Common	X
Sida cordifolia L.	Pantropic Sida	Frequent	I
S. spinosa L.	Prickly Sida	Common	X
STERCULIACEAE			
Waltheria americana L.	Hi'aloa	Common	I
FLACOURTIACEAE			
Xylosma hawaiiense Seem.		Rare	E
PASSIFLORACEAE			
Passiflora edulis Sims	Lilikoi	Common	X
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Opuntia megacantha Salm-Dyck	Panini, Prickly pear	Rare	X
MYRTACEAE			
Eucalyptus robusta Sm.	Swamp mahogany	Abundant	X
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ARALIACEAE			
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Foeniculum vulgare Mill.	Sweet fennel	Abundant	X
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EBENACEAE			
Diospyros ferrea var. *degeneri* f. *lanaiensis* Fosb.	Lama	Abundant	E
OLEACEAE			
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Thevetia peruviana (Pers.) K. Schum.	Be-still tree, yellow oleander	Common	X
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Ipomoea cairica (L.) Sweet	Koali	Frequent	I
I. congesta R. Br.	Koali'awania, Morning glory	Frequent	I
Jacquemontia sandwicensis Gray	Pa'uohi'iāka	Rare	E

Table 4 (Continued.)

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
VERBENACEAE			
Lantana camara L.	Lantana	Abundant	E
Stachytarpheta jamaicensis (L.) Vahl	Ōwī, Jamaica vervain	Frequent	X
Verbena litoralis HBK.	Vervain	Rare	X
LAMIACEAE (Labiatae)			
Salvia coccinea Juss. ex Murr.	Līlīlehua, Scarlet sage	Common	X
Stachys arvensis L.	Staggerweed	Rare	X
SOLANACEAE			
Nothocestrum latifolium Gray		Rare	E
Physalis peruviana L.	Pohā, Husk tomato	Frequent	X
Solanum sodomeum L.	Thorny pōpolo, Apple of Sodom	Common	X
MYOPORACEAE			
Myoporum sandwicense var. *lanaiense* Webster	Naio	Frequent	E
PLANTAGINACEAE			
Plantago lanceolata L.	Narrow-leaved plantain	Frequent	X
RUBIACEAE			
Bobea sandwicensis (Gray) Hbd.	'Ahakea	Common	E
Canthium odoratum (Forst. f.) Seem.	Alahe'e	Common	I
Gardenia brighamii Mann	Nānū	Rare	E
CUCURBITACEAE			
Momordica charantia L.	Bitter melon	Rare	X

Table 4 (Continued).

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
ASTERACEAE (Compositae)			
Acanthospermum australe (Loefl.) Ktze.	Kukaehipa, Spiny-bur	Common	X
Ageratum conyzoides L.	Mailehonohono, Ageratum	Rare	X
Bidens pilosa L.	Kīnehe, Begger's tick	Common	X
Cirsium vulgare (Savi) Tenore	Puakala, Bull thistle	Common	X
Emilia sonchifolia (L.) DC.	Lilac pualele	Frequent	X
Erigeron canadensis L.	Ilioha, Canada fleabane	Common	X
Picris hieracioides L.	Hawkesweed	Rare	X
Sonchus oleraceus L.	Pualele, Sowthistle	Rare	X

	#	%
Endemic species	25	30
Indigenous species	8	10
Exotic species	51	60
Total	84	100

The abbreviations for origin are: E = Endemic, I = Indigenous and X = Exotic. The classification of status is: Rare = solitary or few with small cover, Common = few plants with small but obvious cover, Frequent = numerous and cover up to 25 percent, and Abundant = generally large numbers and cover over 25 percent.

Table 4 (Continued.)

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
VERBENACEAE			
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Verbena litoralis HBK.	Vervain	Rare	X
LAMIACEAE (Labiatae)			
Salvia coccinea Juss. ex Murr.	Līlīlehua, Scarlet sage	Common	X
Stachys arvensis L.	Staggerweed	Rare	X
SOLANACEAE			
Nothocestrum latifolium Gray		Rare	E
Physalis peruviana L.	Pohā, Husk tomato	Frequent	X
Solanum sodomeum L.	Thorny pōpolo, Apple of Sodom	Common	X
MYOPORACEAE			
Myoporum sandwicense var. *lanaiense* Webster	Naio	Frequent	E
PLANTAGINACEAE			
Plantago lanceolata L.	Narrow-leaved plantain	Frequent	X
RUBIACEAE			
Bobea sandwicensis (Gray) Hbd.	'Ahakea	Common	E
Canthium odoratum (Forst. f.) Seem.	Alahe'e	Common	I
Gardenia brighamii Mann	Nānū	Rare	E
CUCURBITACEAE			
Momordica charantia L.	Bitter melon	Rare	X

Table 4 (Continued).

Family Scientific Name	Common Name	Status at Kānepu'u	Origin
ASTERACEAE (Compositae)			
Acanthospermum australe (Loefl.) Ktze.	Kukaehipa, Spiny-bur	Common	X
Ageratum conyzoides L.	Mailehonohono, Ageratum	Rare	X
Bidens pilosa L.	Kīnehe, Begger's tick	Common	X
Cirsium vulgare (Savi) Tenore	Puakala, Bull thistle	Common	X
Emilia sonchifolia (L.) DC.	Lilac pualele	Frequent	X
Erigeron canadensis L.	Ilioha, Canada fleabane	Common	X
Picris hieracioides L.	Hawkesweed	Rare	X
Sonchus oleraceus L.	Pualele, Sowthistle	Rare	X

	#	%
Endemic species	25	30
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Total	84	100

The abbreviations for origin are: E = Endemic, I = Indigenous and X = Exotic. The classification of status is: Rare = solitary or few with small cover, Common = few plants with small but obvious cover, Frequent = numerous and cover up to 25 percent, and Abundant = generally large numbers and cover over 25 percent.

area. The most obvious would be to build a deer-proof fence. However, the cost of such a fence would almost preclude its construction.

Unfortunately, there is a State maintained watering trough located just outside the southeastern edge of the windbreak which attracts deer to this area. The removal of the trough would go a long way towards minimizing the impact of axis deer in Kānepu'u.

Finally, the Land Use Commission recently rezoned 3,100 acres of this area from Agricultural to Conservation. Munro (1952) has already proposed that the area be preserved. If this were done it would be fitting to do so in his honor.

It is important that the Kānepu'u woodland be allowed to maintain itself. The woodland is the best example of this vegetation type in the Hawaiian Islands. It also provides the habitat for the small but best remaining population of the fragrant dryland *Gardenia* or nānū.

ACKNOWLEDGEMENTS

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PUUKOHOLA HEIAU NATIONAL HISTORIC SITE PLANT SURVEY

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INTRODUCTION

By 1789, Kamehameha I had fallen short of his ambition to conquer the Hawaiian Islands. Though he had conquered Maui, Moloka'i and Lāna'i, he was not the sole ruler on his home island of Hawai'i. Wishing to break the *status quo* he dispatched his aunt to Kaua'i to consult with Kāpoūkahi, a famous prophet. Kāpoūkahi said that in order to achieve his ambition he must build a large heiau to the family war god, Kūkā'ilimoku, at Pu'ukoholā. The work was begun in 1790 and finished in 1791. The prophecy was fulfilled. Thus the heiau is of considerable significance in Hawaiian history.

In 1975, we were contracted by the Cooperative National Park Resources Studies Unit at the University of Hawaii to conduct a floristic survey of Puukohola Heiau National Historic Site. This report is an abbreviated version of our final report (Macneil and Hemmes 1977).

Geographical Location and Climate

Puukohola Heiau National Historic Site is located approximately one mile south of Kawaihae at the base of the western slope of Kohala Mountain on the leeward side of the island of Hawai'i (Fig. 1). The 77-acre (31-hectare) site consists of a gently undulating landscape with a maximum elevation of 135 feet (41 m) descending to sea level. The area is bordered on the west by ocean and to the south by the Samuel M. Spencer County Beach Park and undeveloped savannah. The eastern boundary runs approximately parallel to Hawaii State Highway 27. This arid coastal zone boasts the lowest per annum precipitation (7.45 inches [189 mm]/year) in the state of Hawai'i, due to the rain shadow produced by Kohala Mountain which rises 5,500 feet (1675 m) above sea level to the north and northeast, blocking the predominant trade winds. Mauna Kea (13,796 feet [4205 m]) and Hualālai (8,271 feet [2521 m]) are situated to the southeast and south, respectively, and also play a role in producing the arid environment. There is a definite fluctuation in rainfall between the summer and winter months. The majority of the rainfall occurs during the months of January and February, when cyclonic cold fronts (Kona storms) from the south converge over the hot land mass on the leeward slopes (Blumenstock and Price 1972). During the rest of the year when the tradewinds predominate, the

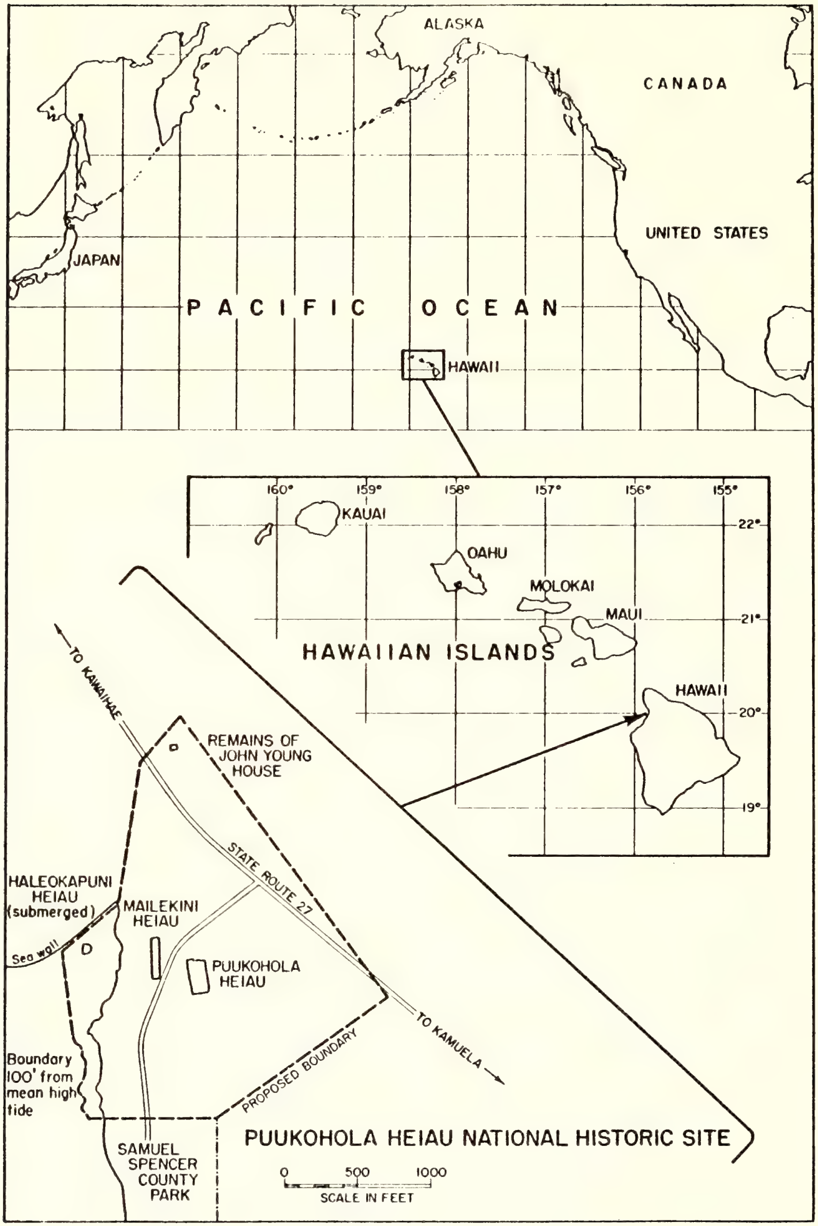
ALASKA
CANADA
UNITED STATES
JAPAN
PACIFIC OCEAN
HAWAII
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
OAHU
MOLOKAI
MAUI
HAWAII
HAWAIIAN ISLANDS
TO KAWAIHAE
REMAINS OF JOHN YOUNG HOUSE
STATE ROUTE 27
HALEOKAPUNI HEIAU (submerged)
MAILEKINI HEIAU
Sea wall
D
PUUKOHOLA HEIAU
TO KAMUELA
Boundary 100' from mean high tide
PROPOSED BOUNDARY
SAMUEL SPENCER COUNTY PARK
PUUKOHOLA HEIAU NATIONAL HISTORIC SITE
0
500
1000
SCALE IN FEET

Figure 1. Map showing the location of Puukohola Heiau National Historic Site, its environs, and the three heiau. The Site has an area of approximately 77 acres (31 hectares), and is situated one mile south of Kawaihae. A small section of ocean extending about 100 feet (30.5 m) from the 700 yards (630 m) of shoreline was originally proposed as being part of the Site.

rainfall is light, very infrequent, and sufficient only to settle the dust.

The mean annual temperature of Pu'ukoholā is 76°F (24°C) with the highest temperatures recorded during September. The annual variations in photoperiod and altitude of the sun above the horizon are slight, thus producing a relatively constant insolation which fluctuates by only a third from its maximum to minimum intensity each year. This slight fluctuation is in part responsible for the small variation in the area's temperature (Blumenstock and Price 1972).

Soil

The soil at the Pu'ukoholā Site is a red desert laterite soil and falls into the Kawaihae soil family. This soil type has been most aptly described as follows: "the A_1 horizon is very weak, thin, and reddish brown, probably formed from the weathering of a thin deposition of volcanic ash or cinders. This overlies unweathered rocks coated with $CaCO_3$ leached from the A_1 horizon" (Sherman 1972). A soil analysis of Pu'ukoholā is presented in Table 1. The soil permeability is classified as moderate and the moisture storage capacity relatively low (1.5 inch/foot soil).

History

Historical analyses of the pre-contact flora by Rock (1913) and Carlquist (1970) describe the arid coastal vegetation zone as consisting predominately of the following species: pā'ū-o-Hi'iaka (*Jacquemontia sandwicensis*), pili (*Heteropogon contortus*), 'ilima (*Sida fallax*), and kākonakona (*Panicum torridum*).

With the onset of contact with western civilization great changes in the native flora began to occur. In 1793, Capt. George Vancouver left cattle, cheep, and goats on the island of Hawai'i. Kamehameha I imposed a kapu on their slaughter and the change in native vegetation began (Handy and Handy 1972).

The sandalwood trade (St. John 1947) and the immigration of missionaries in the first quarter of the 19th century, combined with the increasing use of Kawaihae Harbor as a port of entry, facilitated the introduction of many species. These new introductions rapidly invaded their new environment and soon produced a new vegetation community.

METHODS

Numerous search and collection expeditions were carried out throughout the site in May 1975, the dry season, and in March 1976, a month after several heavy rain storms of 1-2 inches (25-50 mm) each. To aid in a complete coverage of the 77 acres (31 hectares), four arbitrary sections were designated and surveyed systematically. Representative plants were

TABLE 1

PHYSICO-CHEMICAL ANALYSIS OF SOIL FROM PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

Percent water	10.4
Paste pH	7.82
Ca	3360.0 ppm
Mg	930.0 ppm
K	1300.0 ppm
P	19.1 ppm

SOURCE: Beaumont Agricultural Research Center, Hilo, Hawai'i. Laboratory sample #142-2-76.

collected and pressed for identification. All specimens after identification were sent to Dr. Derral Herbst, Lyon Arboretum, University of Hawaii, Honolulu, for verification. Herbarium sheets of a representative collection of all the plants collected will be deposited at Puukohola Heiau National Historic Site. To avoid unnecessary confusion, the nomenclature used in this report follows St. John (1973). Though we do not necessarily agree with some of the nomenclature, this work is the most complete list of Hawaiian plant names to date. The rare and endangered species lists also use this nomenclature. There is one exception to this usage. St. John recognizes *Pennisetum setosum* and *Cenchrus ciliaris*, which are probably the same taxon. To avoid confusion, we have used the name *Pennisetum ciliare* following the suggestion of Fosberg (personal communication).

Nineteen 15-meter transects were spaced at 100-meter intervals along State Highway 27 and Spencer Beach Park County Road to monitor roadside introductions. Transect #1 was situated at a position one meter to the north of the entrance to the Site's headquarters and ran perpendicular to State Highway 27 in an easterly direction. The remaining 18 transects fall in an alternate pattern whereby each successive transect runs perpendicular to the roadway, but on the opposite side of the road from the previous one.

The relative abundance of the existing flora along each transect was determined by placing one-meter-square quadrats on alternate sides at every two-meter interval along each transect line. Quadrat #1 was always placed on the northern side of the line, thus situating quadrat #3* on the southern side, quadrat #5 on the northern side, etc. Each quadrat was divided into 100 points to give the relative percentage of encountered species.

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*Quadrat #3 is the second quadrat, #5 is the third, etc. Their numbers correspond to their distance in meters from the road.

RESULTS

Species Inventory

A checklist of all plant species recorded within the confines of Puukohola Heiau National Historic Site during the dry season, May 1975, and the wet season, March 1976, is presented in Table 2. Species observed only during the wet season are indicated by an asterisk (*). A total of 50 species representing 21 Angiosperm families were found along with 2 ferns and a Lycoperdales (puff-ball). After each species the status--i.e. whether introduced, indigenous, or endemic (according to St. John [1973]) --is recorded, along with its relative abundance and distribution at the Historic Site. Of the total number of species collected, 37 are introductions, 10 are indigenous, 5 are endemic, and 1 is yet to be positively identified, but it is probably an introduction.

Vegetation Communities

Four distinct plant communities can be recognized within the boundaries of Puukohola Heiau National Historic Site. The vegetation map (Fig. 2) shows the sharp demarcation between the open xeric grassland surrounding Pu'ukoholā Heiau and the lower elevation coastal forest. To the north, this forest forms a protective canopy over the third community: a brackish water pond and extensive salt marsh which extends several hundred yards inland from the back berm of the sand beach. The disturbed roadside community was recognized as a fourth vegetation community type.

1. *Scrub-grassland community*

The xeric, open scrub-grassland environment is the predominant community type. It is dominated by the grass feathery pennisetum (*Pennisetum ciliare*), and by scattered low stature shrubs of kiawe (*Prosopis pallida*). Within this community scattered low density populations of slender mimosa (*Desmanthus virgatus*), fountaingrass (*Pennisetum setaceum*), koa-haole (*Leucaena leucocephala*), 'ilima (*Sida fallax*), morning glory (*Ipomoea congesta*), and hairy merremia (*Merremia aegyptia*) are found. The habit and cover of these species fluctuates greatly according to the time of the year. During the summer, vegetative die-back is extensive as this area dries out, but during the few months of the "wet" winter season a dramatic "greening" and burst of vegetative growth occurs. Though encountered rarely, the xerophytic Basidiomycete (*Battarrea phalloides*) and the endemic pā'ū-o-Hi'iaka (*Jacquemontia sandwicensis*) were collected in this community type.

2. *Closed kiawe forest*

This forest community is found in areas where ground water provides a relatively constant soil moisture content throughout the year. The community contains a diverse flora and can be subdivided into two types, coastal and fluvial.

TABLE 2

SPECIES CHECKLIST FOR PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

Scientific Name	Common Name	Status	Abundance
PTERIDOPHYTES (Ferns)			
OPHIOGLOSSACEAE			
**Ophioglossum concinnum* Brack.	Pololei, pololoi, adder's tongue	E	Rare
ADIANTACEAE			
**Doryopteris decora* Brack.	'Iwa'iwa, kumu-niu, manawahua	E	Rare
ANGIOSPERMS (Flowering Plants)			
GRAMINEAE (POACEAE)	GRASS FAMILY		
Aristida adscensionis L.	Sixweeks threeawn	X	Infrequent
Chloris inflata Link	Swollen fingergrass, mau'ulei	X	Infrequent
**Chloris virgata* Sw.	Feather fingergrass	X	Infrequent
**Eragrostis cilianensis* (All.) Vignolo-Lutati	Stinkgrass	X	Rare
Panicum maximum Jacq.	Guinea grass	X	Rare
Pennisetum setaceum (Forsk.) Chiov.	Fountaingrass	X	Common
Pennisetum ciliare (L.) Link	Feathery pennisetum, buffelgrass	X	Abundant
Rhynchelytrum repens (Willd.) C.E. Hubb.	Natal redtop	X	Infrequent
Setaria verticillata (L.) Beauv.	Bristly foxtail	X	Rare
PALMAE (ARECACEAE)	PALM FAMILY		
Cocos nucifera L.	Coconut, niu	X	Rare

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
PALMAE (ARECACEAE)	PALM FAMILY		
Phoenix canariensis Hort. ex Chabaud	Canary Is. date palm	X	Rare
CHENOPODIACEAE	GOOSEFOOT FAMILY		
**Atriplex? johnstonii* Wolf	Saltbush	X	Rare
**Atriplex muelleri* Benth.	Saltbush	X	Infrequent
Atriplex semibaccata R.Br.	Australian saltbush	X	Infrequent
Chenopodium murale L.	Nettle-leaved goosefoot	X	Infrequent
Chenopodium oahuense (Meyen) Aellen	'Āheahea	E	Rare
AMARANTHACEAE	AMARANTH FAMILY		
Amaranthus dubius Mart.	Pakai, spleen amaranth	X	Infrequent
NYCTAGINACEAE	FOUR O'CLOCK FAMILY		
**Boerhavia diffusa* L.	Alena	I	Rare
BATIDACEAE	BATIS FAMILY		
Batis maritima L.	Saltwort, 'ākulikuli-kai	X	Rare
AIZOACEAE	CARPETWEED FAMILY		
Sesuvium portulacastrum (L.) L.	Sea purslane, 'ākulikuli	I	Rare
PORTULACACEAE	PURSLANE FAMILY		
Portulaca cyanosperma Egler	'Ihi, blue-seeded portulaca	E	Infrequent
**Portulaca oleracea* L.	Wild portulaca, pigweed	X	Rare

TABLE 2

SPECIES CHECKLIST FOR PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

Scientific Name	Common Name	Status	Abundance
PTERIDOPHYTES (Ferns)			
OPHIOGLOSSACEAE			
*_Ophioglossum concinnum_ Brack.	Pololei, pololoi, adder's tongue	E	Rare
ADIANTACEAE			
*_Doryopteris decora_ Brack.	'Iwa'iwa, kumu-niu, manawahua	E	Rare
ANGIOSPERMS (Flowering Plants)			
GRAMINEAE (POACEAE)	GRASS FAMILY		
Aristida adscensionis L.	Sixweeks threeawn	X	Infrequent
Chloris inflata Link	Swollen fingergrass, mau'ulei	X	Infrequent
*_Chloris virgata_ Sw.	Feather fingergrass	X	Infrequent
*_Eragrostis cilianensis_ (All.) Vignolo-Lutati	Stinkgrass	X	Rare
Panicum maximum Jacq.	Guinea grass	X	Rare
Pennisetum setaceum (Forsk.) Chiov.	Fountaingrass	X	Common
Pennisetum ciliare (L.) Link	Feathery pennisetum, buffelgrass	X	Abundant
Rhynchelytrum repens (Willd.) C.E. Hubb.	Natal redtop	X	Infrequent
Setaria verticillata (L.) Beauv.	Bristly foxtail	X	Rare
PALMAE (ARECACEAE)	PALM FAMILY		
Cocos nucifera L.	Coconut, niu	X	Rare

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
PALMAE (ARECACEAE)	PALM FAMILY		
Phoenix canariensis Hort. ex Chabaud	Canary Is. date palm	X	Rare
CHENOPODIACEAE	GOOSEFOOT FAMILY		
*_Atriplex? johnstonii_ Wolf	Saltbush	X	Rare
*_Atriplex muelleri_ Benth.	Saltbush	X	Infrequent
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Chenopodium murale L.	Nettle-leaved goosefoot	X	Infrequent
Chenopodium oahuense (Meyen) Aellen	'Āheahea	E	Rare
AMARANTHACEAE	AMARANTH FAMILY		
Amaranthus dubius Mart.	Pakai, spleen amaranth	X	Infrequent
NYCTAGINACEAE	FOUR O'CLOCK FAMILY		
*_Boerhavia diffusa_ L.	Alena	I	Rare
BATIDACEAE	BATIS FAMILY		
Batis maritima L.	Saltwort, 'ākulikuli-kai	X	Rare
AIZOACEAE	CARPETWEED FAMILY		
Sesuvium portulacastrum (L.) L.	Sea purslane, 'ākulikuli	I	Rare
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Portulaca cyanosperma Egler	'Ihi, blue-seeded portulaca	E	Infrequent
*_Portulaca oleracea_ L.	Wild portulaca, pigweed	X	Rare

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
PASSIFLORACEAE	PASSION FLOWER FAMILY		
Passiflora foetida L.	Scarlet-fruited passionflower, pōhapōha	X	Rare
CONVOLVULACEAE	MORNING-GLORY FAMILY		
Ipomoea brasiliensis (L.) Sweet (more commonly known as *I. pes-caprae*)	Beach morning-glory, pōhuehue	I	Rare
Ipomoea congesta R.Br.	Morning-glory, koali-'awahia	I	Rare
Jacquemontia sandwicensis var. *tomentosa* f. *hosakae* Deg. & Deg.	Pā'ū-o-Hi'iaka	E	Rare
Merremia aegyptia (L.) Urban	Hairy merremia, koali-kua-hulu	X	Infrequent
BORAGINACEAE	HELIOTROPE FAMILY		
Heliotropium curassavicum L.	Nena, kīpūkai, seaside heliotrope	I	Rare
Messerschmidia argentea (L. f.) Johnston	Tree heliotrope, velvet leaf	X	Rare
SOLANACEAE	NIGHTSHADE FAMILY		
Lycopersicon pimpinellifolium Mill.	Currant tomato, 'ōhi'a-ma-kanahele	X	Rare
CUCURBITACEAE	GOURD or SQUASH FAMILY		
Citrullus sp.	ipu	X	Rare
GOODENIACEAE	NAUPAKA FAMILY		
Scaevola taccada (Gaertn.) Roxb.	Naupaka-kahakai	I	Rare
COMPOSITAE (ASTERACEAE)	SUNFLOWER FAMILY		
Bidens cynapifolia HBK.	West Indian beggar's tick	X	Infrequent

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
CAPPARACEAE	CAPER FAMILY		
Gynandropsis gynandra (L.) Briq.	African spiderflower, honohina	X	Rare
LEGUMINOSAE (FABACEAE)	PEA FAMILY		
Desmanthus virgatus (L.) Willd.	Slender mimosa	X	Infrequent
Leucaena leucocephala (Lam.) de Wit	Koa-haole	X	Infrequent
Prosopis pallida (Humb. & Bonpl. ex Willd.) HBK.	Kiawe	X	Common
ZYGOPHYLLACEAE	TRIBULUS FAMILY		
**Tribulus cistoides* L.	Nohu, large-flowered caltrop	I	Rare
**Tribulus terrestris* L.	Puncture vine	X	Infrequent
EUPHORBIACEAE	SPURGE FAMILY		
**Euphorbia geniculata* Ortega	Wild spurge, kaliko	X	Infrequent
Euphorbia hirta L.	Hairy spurge, koko-kahiki	X	Infrequent
Ricinus communis L.	Castor bean, kolī	X	Infrequent
MALVACEAE	MALLOW FAMILY		
Abutilon grandifolium (Willd.) Sweet	Hairy abutilon, ma'o	X	Infrequent
Sida fallax Walp.	'Ilima	I	Infrequent
Thespesia populnea (L.) Soland. ex Correa	Milo	I	Rare
STERCULIACEAE	COCOA FAMILY		
Waltheria americana L.	Hi'a-loa, 'uha-loa	I	Common

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
PASSIFLORACEAE	PASSION FLOWER FAMILY		
Passiflora foetida L.	Scarlet-fruited passionflower, pōhapōha	X	Rare
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Merremia aegyptia (L.) Urban	Hairy merremia, koali-kua-hulu	X	Infrequent
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Messerschmidia argentea (L. f.) Johnston	Tree heliotrope, velvet leaf	X	Rare
SOLANACEAE	NIGHTSHADE FAMILY		
Lycopersicon pimpinellifolium Mill.	Currant tomato, 'ōhi'a-ma-kanahele	X	Rare
CUCURBITACEAE	GOURD or SQUASH FAMILY		
Citrullus sp.	ipu	X	Rare
GOODENIACEAE	NAUPAKA FAMILY		
Scaevola taccada (Gaertn.) Roxb.	Naupaka-kahakai	I	Rare
COMPOSITAE (ASTERACEAE)	SUNFLOWER FAMILY		
Bidens cynapifolia HBK.	West Indian beggar's tick	X	Infrequent

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TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
CAPPARACEAE	CAPER FAMILY		
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Euphorbia hirta L.	Hairy spurge, koko-kahiki	X	Infrequent
Ricinus communis L.	Castor bean, kolī	X	Infrequent
MALVACEAE	MALLOW FAMILY		
Abutilon grandifolium (Willd.) Sweet	Hairy abutilon, ma'o	X	Infrequent
Sida fallax Walp.	'Ilima	I	Infrequent
Thespesia populnea (L.) Soland. ex Correa	Milo	I	Rare
STERCULIACEAE	COCOA FAMILY		
Waltheria americana L.	Hi'a-lōa, 'uha-loa	I	Common

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
COMPOSITAE (ASTERACEAE)	SUNFLOWER FAMILY		
Emilia sonchifolia (L.) DC.	Lilac pua-lele	X	Rare
Gnaphalium peregrinum Fern.		X	Rare
Sonchus oleraceus L.	Sow thistle, pua-lele	X	Rare
Tridax procumbens L.	Coat buttons	X	Rare
	FUNGI		
LYCOPERDALES	PUFF-BALLS		
Battarrea phalloides (Dicks.) Pers.		X	Rare

NOTE:

STATUS

E = Endemic (native, found only in Hawai'i)
I = Indigenous (native, but not unique to Hawai'i)
X = Exotic (introduced)

* Found only in wet season.

ABUNDANCE

Rare = only occasional plants found in area
Infrequent = few plants, generally in localized areas
Common = plants frequently found in most areas
Abundant = very numerous

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
COMPOSITAE (ASTERACEAE)	SUNFLOWER FAMILY		
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Gnaphalium peregrinum Fern.		X	Rare
Sonchus oleraceus L.	Sow thistle, pua-lele	X	Rare
Tridax procumbens L.	Coat buttons	X	Rare
FUNGI			
LYCOPERDALES	PUFF-BALLS		
Battarrea phalloides (Dicks.) Pers.		X	Rare

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ABUNDANCE

Rare = only occasional plants found in area
Infrequent = few plants, generally in localized areas
Common = plants frequently found in most areas
Abundant = very numerous

Coastal closed forest. This closed forest of tall kiawe (*Prosopis pallida*) borders the ocean from the south end of the beach below Hale o Kapuni Heiau to Spencer Beach Park. Because of its thick canopy, only sparse populations of feathery pennisetum (*Pennisetum ciliare*), 'ilima (*Sida fallax*), and hairy abutilon (*Abutilon grandifolium*) occur under the trees.

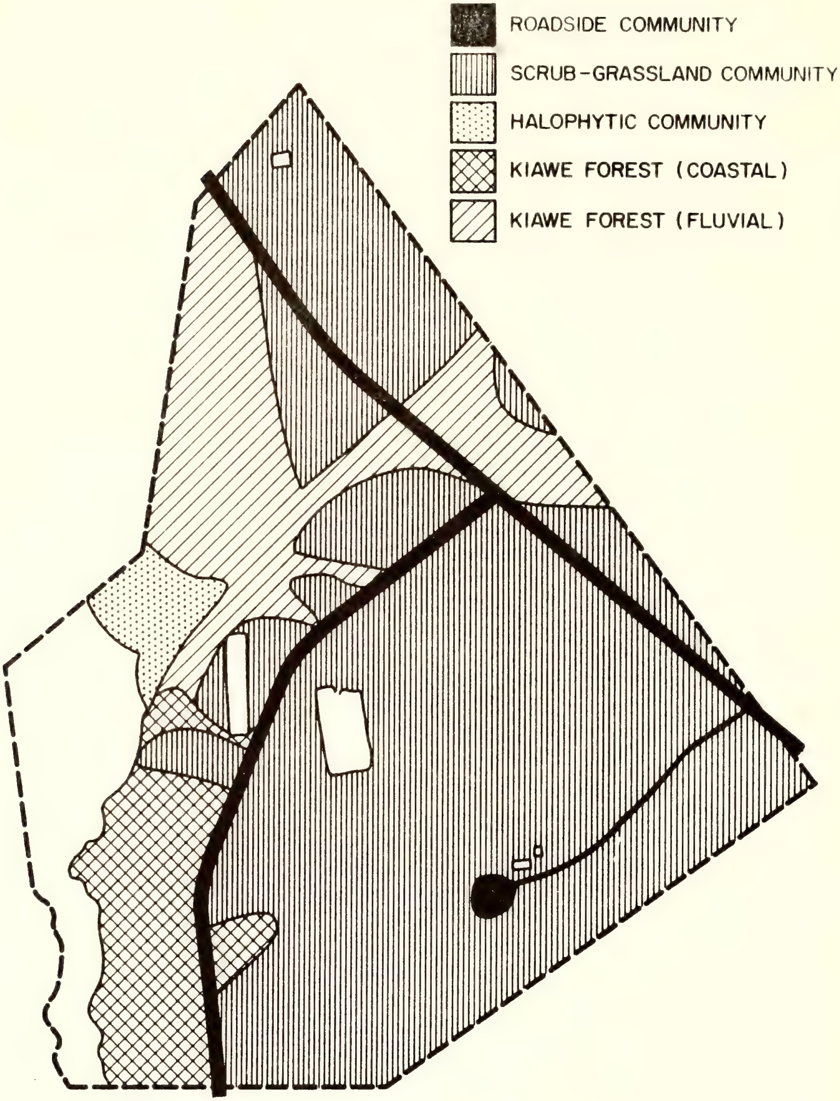
Fluvial closed forest. This community borders Makeāhua Gulch and extends through the northern portions of the Site. It also consists of a forest of tall kiawe (*Prosopis pallida*) intermixed with vigorously growing specimens of natal redtop (*Rhynchelytrum repens*), bristly foxtail (*Setaria verticillata*), guinea grass (*Panicum maximum*), nohu (*Tribulus cistoides*), puncture vine (*Tribulus terrestris*), wild spurge (*Euphorbia geniculata*), coat buttons (*Tridax procumbens*), and pua-lele or sow thistle (*Sonchus oleraceus*).

3. *Halophytic community*

This community of salt-tolerant plants is located around the brackish pond, within the marsh and beach area at the northwestern end of the Site. This area is of fluvial origin and cannot be more than 10 to 15 feet (3 to 5 m) above sea level at its highest point. It extends in a narrow strip for nearly 200 yards (180 m) inland from the small sand beach. The community merges with the closed forest zone. The beach has a scattered population of Australian saltbush (*Atriplex muelleri*) of relatively low habit. Scattered seedlings of kiawe (*Prosopis pallida*) and milo (*Thespesia populnea*) grow not more than 25 feet (7.5 m) from the sea on the beach during the winter months. Toward the berm of the beach, stands of beach morning glory (*Ipomoea brasiliensis*) and naupaka-kahakai (*Scaevola taccada*) appear. These immediately give way to marsh bordered on the south by a closed forest of well-established kiawe (*Prosopis pallida*) interspersed with tall representatives of coconut (*Cocos nucifera*) and tree heliotrope (*Messerschmidia argentea*). The understory vegetation is comprised of scattered passion flower (*Passiflora foetida*), wild portulaca (*Portulaca oleracea*), and feathery pennisetum (*Pennisetum ciliare*). Numerous young specimens of kiawe (*Prosopis pallida*) may also be observed, yet most of the ground cover is shaded and devoid of vegetation. The marsh area, between the pond and the beach, contains large populations of sea purslane or 'ākulikuli (*Sesuvium portulacastrum*) and saltwort (*Batis maritima*), as well as scattered representatives of nena (*Heliotropium curassavicum*), hairy spurge (*Euphorbia hirta*), and pakai (*Amaranthus dubius*). Near the brackish pond young Canary Island date palm (*Phoenix canariensis*) as well as 'āheahea (*Chenopodium oahuense*) are located. Vigorously growing populations of Australian saltbush (*Atriplex semibaccata*) and another saltbush (*Atriplex muelleri*) are found around the periphery of the pond and are much more robust than those populations encountered on the beach.

4. *Roadside community*

A strip of land about five meters wide bordering all roads was considered a separate community. This community is heavily disturbed from road-building activities and continues to be affected by both vehicular


ROADSIDE COMMUNITY
SCRUB-GRASSLAND COMMUNITY
HALOPHYTIC COMMUNITY
KIAWE FOREST (COASTAL)
KIAWE FOREST (FLUVIAL)

SCALE: 1 inch = 500 feet

Figure 2. Vegetation map of the major plant communities at Puukohola Heiau National Historic Site.

and pedestrian traffic. Though much of the community would be a scrub-grassland under natural conditions, the disturbance has produced a community with a very depleted complement of species. There are only twelve species present and none are unique to this habitat. Further from the road, that is, beyond five meters, the number of species present begins to increase, indicating that the effects of disturbance are decreasing.

Noteworthy Species

There are two noteworthy species present in the study area. The rare endemic fern *Ophioglossum concinnum* (pololei), proposed for inclusion in the federal listing of rare and endangered plants, grows in a small area just off the main highway. Also a saltbush, tentatively called *Atriplex johnstonii* Wolf by Dr. F. R. Fosberg, Smithsonian Institution, was collected for the first time in Hawai'i. Several plants were found growing on the sandy beach.

DISCUSSION

The vegetation in the arid coastal vegetation zone has undergone considerable alteration since 1788. Rock (1974) and Carlquist (1970) list 'ilima, pili, Kākonakona, and pā'u-o-Hi'iaka as the dominant elements of the flora. To this list we can probably add the indigenous and endemic plants that are there today, i.e., 'āheahea, alena, 'ākulikuli, 'ihi, nohu, milo, hi'a-loa, pōhuehue, koali-'awahia nena, and naupaka-kahakai. Most of these plants would have been concentrated around the shoreline and the streambed of Makeāhua Gulch. Two grasses from the above list, pili and kākonakona, are no longer present in the Historic Site. They have probably been displaced by the two species of *Pennisetum* which now predominate.

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The authors would like to thank Ms. Deborah Weiner for typing and for her editorial assistance. They also gratefully acknowledge the aid of Dr. C. W. Smith in preparing and editing this report; Dr. C. H. Lamoureux and Ms. Lani Stemmermann for their critical reviews and helpful suggestions; Dr. Derral Herbst, University of Hawaii Lyon Arboretum, for assisting in the plant identification; and Mr. Y. N. Tamimi, University of Hawaii Beaumont Agricultural Research Center, Hilo, for the soil chemical analysis.

This research was supported by NPS Contract #CX8000 6 0031.

MINUTES OF THE REGULAR MEETINGS

The meeting was called to order by the President at 7:30 p.m. on Oct. 4, 1976. The minutes of the June meeting were read and accepted.

The Treasurer reported a

Balance on hand (Jun. 4, 1976)	$551.83
Income of	146.00
Expenses of	18.05
Balance on hand (Oct. 1, 1976)	$679.78

The Society received a $50.00 gift from Dr. Baker.

Dr. Sheila Conant announced the addition to the monthly meetings of a five minute period when members could introduce to the group the Plant of the Month. Members are encouraged to bring in a native plant for a "show and tell."

Dr. Lamoureux showed *Scaevola coriacea* or False jade tree.

Sheila Conant announced that the November speaker will be Dr. Ayensu, Chairman of the Botany Department of the Smithsonian Institute. Dr. Ayensu will speak on his travels in China. This November meeting will be a joint meeting of the Botanical Society and the Pacific Tropical Botanical Society.

The President, Dr. Carr, will be our speaker for the December meeting. The meeting was adjourned at 8 p.m.

Sheila Conant introduced Mark Merlin who spoke on "Human Impact on Costa Rica Ecosystems."

. . . .

The meeting was called to order by the President at 7:40 p.m., Nov. 1, 1976. The guests were introduced and the minutes of the October 4 meeting were read and accepted.

The Treasurer reported a

Balance on hand (Oct. 4, 1976)	$679.78
Income of	0.00
Expenses of	61.00
Balance on hand (Nov. 1, 1976)	$618.78

Sheila Conant announced that Dr. Carr will be the speaker for the December meeting.

Dr. Lamoureux asked for the nominating committee report. Dr. Carr said that the nominating committee report would be included in the announcement of the December meeting.

Steve Montgomery announced that the 18th Annual Forestry Conference would be held at the Ilikai Hotel on November 18 and 19, 1976. Dr. Carr read a letter from Mayor Fasi concerning Arbor Week.

Keith Woolliams showed slides of *Pritchardia monroei* from Moloka'i and spoke of efforts being made to propagate it. The meeting was adjourned at 7:50 p.m.

Sheila Conant introduced Dr. Abbott who spoke on "Food and Food Products from Marine Algae."

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY
C/O DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII
HONOLULU, HAWAII 96822

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Newsletter
Hawaiian Botanical Society

Contents

VOLUME 16 NUMBER 1/2 FEBRUARY/APRIL 1977

ANDROPOGON VIRGINICUS (BROOMSEDGE)
by James Sorenson 7

ENDANGERED HAWAIIAN PLANTS
by Derral Herbst 22

BRIEF REPORTS AND NOTES

SOCIETY BUSINESS...2,3,29,30,32; *Montgomery* - KĀNEPU'U DRYLAND FOREST...4; *Hoe* - BOOK REVIEW...5; EDITOR'S NOTE...6.

*

Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

ANNUAL REPORT OF THE SECRETARY FOR 1976

The Society held regular general membership meetings on the first Monday of each month, except July, August and September, in room 11 of St. John Plant Science Building, University of Hawaii.

In February 1976, the Society awarded honorary membership status to Donald Anderson, Gladys Baker, Helen Baldwin, Vladimir Krajina and Lorraine Kuck.

During that same month we gave two copies of Dr. Rock's "Indigenous Trees of Hawaii" to Science Fair winners whose projects were of Botanical interest.

During the year the Society held two plant exchanges, one in March, supervised by Mr. Ted Green and one in November, conducted by Hildi Cherry. These events helped provide the money to pay for the refreshments served at each meeting.

In October Dr. Baker sent the Society a gift of $50.00.

Dr. Clifford Smith took over the editorship of the Newsletter from Mr. Bill Hoe.

In May a new committee within the Society was formed. Its purpose is to stimulate public interest and awareness in rare and endangered species of native Hawaiian plants. Dr. Dan Palmer subsequently became chairman of this committee.

In October a new feature was added to the regular meetings, i.e. members are encouraged to bring to the meetings and share with the membership either pictures or samples of native Hawaiian plants.

During the year the membership enjoyed talks on a wide variety of topics of botanical interest.

In January Messrs. Steven Montgomery and Glen Spence showed slides and discussed the "Natural Area Reserve Potential of the Pu'u Wa'aWa'a Dryland Forest, Hawai'i."

In February Mrs. Betsy Gagné gave a slide show on some plants of New Guinea.

Our past president, Dr. William Theobald, now Director of the Pacific Tropical Botanical Garden, discussed, with suitable slides, the future plans and development of the Garden.

In April we were given a look at "Ornamental Horticulture in Denmark" by Mr. Glenn Teves of the UH Horticulture Department. He had spent some time traveling and studying in that country.

The interesting and useful work now being carried on at the Waimea Arboretum with native and endangered plants was the subject of a talk by Keith Woolliams of that institution at our May meeting.

One of our most colorful slide shows was given by Mr. Oscar Kirsch at the June meeting. Mr. Kirsch's topic was "Orchids in Hawaii."

The General Science Department of the University of Hawaii provided our speaker for the October meeting. Mr. Mark Merlin discussed the "Human Impact on Costa Rica Ecosystems" and showed slides he had taken while studying in that country.

In November Dr. Isabella A. Abbott discussed "Food and Food Products of Marine Algae."

The Presidential address was presented at the December meeting by Dr. Gerald Carr who spoke on "Ohikilolo or Bust: or, The true story of how a biosystematist fell for Hawaii." At the December meeting the following members were elected to office:

Mr. Ted Green - President
Dr. Sheila Conant - Vice-President
Dr. Charles Lamoureux - Treasurer
Ms. Karen Shigematsu - Secretary

Mr. Ted Green, on behalf of the Society, thanked the retiring officers for their hard work. He asked the appointed officers of the Society to continue in their posts.

Evangeline Funk, Secretary

ANNUAL REPORT OF THE TREASURER

December 1, 1976 - November 30, 1976

RECEIPTS:		
Dues and gifts	$1004.00	
Total receipts		1004.00
EXPENDITURES:		
Postage	215.62	
Supplies	29.48	
Newsletter	867.55	
Returned checks	9.00	
Total expenditures		1121.65
Cash flow during year		(-117.65)

BALANCES IN BANKS AND SAVINGS ACCOUNTS

First Hawaiian Bank Commercial Account	
Balance, Nov. 30, 1975	638.37
Deposits, Dec. 1, 1975 - Nov. 30, 1976	999.50
Withdrawals, Dec. 1, 1975 - Nov. 30, 1976	1117.15
Balance, Nov. 30, 1976	520.72

First Federal Savings and Loan, Marie C. Neal Memorial Account	
Balance, Nov. 30, 1975	12,266.25
Interest earned, Dec. 1, 1975 - Nov. 30, 1976	662.98
Balance, Nov. 30, 1976	12,929.23

First Federal Savings and Loan, Savings Account	
Balance, Nov. 30, 1975	133.98
Interest earned, Dec. 1, 1975 - Nov. 30, 1976	7.24
Balance, Nov. 30, 1976	141.22

Charles H. Lamoureux, Treasurer

USE AND KNOWLEDGE OF THE KĀNEPU'U DRYLAND FOREST BY LĀNA'I RESIDENTS

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University of Hawaii

A survey of Lāna'i residents' knowledge of and uses for the native dryland forest was coordinated by Michael McClellan, Carole Ching Dunn and Kathleen Miyasaki. Nearly 12% of the 2200 residents of Lāna'i were reached during June 1971, in a door to door survey. Most residents called the region the "North End" or the "Lone Pine Area" and were unfamiliar with the place name "Kānepu'u" which is a knoll adjacent to the forest stands. About 22% of the residents responded that they did use the Kānepu'u area for outings and an access route to the beach, and purposes other than hunting. When asked what plants they knew from there, only 10% gave any specific and accurate reply. When asked "whether it would be good to put more pineapple in Kānepu'u, 43% responded in the negative, 14% positive, and a high 43% no comment. When queried whether they would like to see Kānepu'u preserved, 19% answered no, 31% yes, and 49% no comment.

Archaeological references note only an ulumaika course and an oven in the vicinity. We located an unusual shrine-like structure in a section of forest at 1700 feet near the head of Kahua Gulch.

BOOK REVIEW

"MOSSES OF THE SOCIETY ISLANDS" by Henry O. Whittier, 410 pp. (incl. 101 fig.), Gainesville: The University Presses of Florida. $17.50.

The north temperate regions of the Americas, Europe and parts of Asia have had a long tradition of bryological study. This has resulted in the ready availability of rich sources of comparative herbarium materials, countless floras and checklists, and the ability to undertake meaningful studies utilizing bryophyte taxonomy as a tool: ecology, developmental morphology, physiology and the like.

Tropical and sub-tropical areas, however, have not been as fortunate, due in part, no doubt, to their distance from centers of traditional western learning and historically, their difficulty of access. Most of the standard references (and often the only meaningful ones) for these areas are old; in a way, the classics for the Tropical Pacific as Fleischer's (1904-1923) *Die Musci der Flora von Buitenzorg* for Java and Bartram's (1939) *Mosses of the Philippines* nowadays only emphasize our inadequate knowledge of tropical mosses.

Recently, however, modern works have begun to appear for these often floristically diverse and phytogeographically significant areas: Gangulee's (1969-still incomplete) *Mosses of Eastern India and Adjacent Regions*, Robinson's (1975) *The Mosses of Juan Fernandez Islands* and Wang's (1970) *Phytogeography of the Mosses of Formosa*. Whittier's reference is a most useful addition to this growing literature. *Mosses of the Society Islands* is important not only because of the nomenclatural novelties presented but even more so because it brings together in a single work a previously very scattered literature together with meaningful descriptions and illustrations of the taxa. All students of Pacific mosses and phytogeography will find this a most useful text.

The introduction (15 p.) treats the geological setting of the Society Islands and provides a chronology of bryological exploration, while Chapter 2 (pp. 16-38) summarizes the islands' ecology. Most of the remaining pages deal with the systematics of the moss flora. It is difficult for me to assess the strengths and weaknesses of this manual because of my lack of experience with the moss flora of Tahiti; my comments, therefore, are limited to thoughts derived from a reading of his text.

In dealing with a relatively unfamiliar flora as that of the Society Islands, meaningful descriptions and critical illustrations assume a great importance due to a relative paucity of available comparative material. In both respects, Whittier has certainly succeeded. However, an unusual practice which he followed (and initially which annoyed me) has been his writing in semi-sentences, with verbs included. Most illustrations are excellent, although additional habit sketches would have been useful. Whittier has told me that these figures were done over an extended time period and I suspect that this accounts for the unequal presentation of drawings. While clarity is evident, several plates are crowded or over-reduced; two examples of this are his Figure 42, in which five taxa are presented in 35 drawings, and Figure 83, in which three taxa in 40 drawings are squeezed onto a half page--with the remainder of the page blank. These two are pointed out only as the most striking examples to illustrate my point; the vast majority are rationally presented and are readily interpreted. In the text itself, it would have been helpful if page numbers for illustrations were indicated.

The arrangement of families is modified from Brotherus (*in Die Natürlichen Pflanzenfamilien*), but I do not know whose system he is using. For the Hookeriales, however, he has followed Miller's recent revision and recognized a number of families proposed in that treatment. For the limited and largely unfamiliar Society Islands' flora, I believe that an alphabetical arrangement of genera and species would have been preferable, much as Lawton did in her *Moss Flora of the Pacific Northwest*.

One final critical comment: despite a relatively long history of collection, the mosses of the Society Islands are still poorly known and it is likely that further exploration will yield a number of new records for the archipelago. It would have been very useful, therefore, if more critical family and generic descriptions had been provided in order to facilitate recognition of new records. Terse diagnoses are now provided only for families and genera with more than a single representative, but for families with but a single species, only species descriptions are presented.

These comments on possible shortcomings should not be allowed to detract from the value of this book, for it is an excellent reference which should be on the shelves of every student of Pacific botany. *Mosses of the Society Islands* will long remain *the* definitive treatment for the south-eastern Polynesian representatives of this fascinating and too-often overlooked group of plants.

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EDITOR'S NOTE

I have to apologize for the delayed issue of the *Hawaiian Botanical Society Newsletter*. Several factors were involved, some of my doing, some on the part of some authors. This issue is again a double issue as I attempt to get the *Newsletter* up-to-date. Please note that the double issues contain at least 32 pages (double the minimal number of pages in single issues).

C. W. Smith, Editor

ANDROPOGON VIRGINICUS (BROOMSEDGE)

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A study was conducted on the autecological relationships of *Andropogon virginicus* L. in an attempt to consolidate published information on this species with a view to improving our understanding of this aggressive, exotic grass.

Andropogon virginicus L. is a New World species of the tribe Andropogonae in the family Gramineae. It is a tall perennial bunch grass and as a taxon is composed of a number of varieties which are distinguished by minor morphological differences (Fernald 1950). It is known by the common names broomsedge and yellow bluestem (Fernald 1950, Rotar 1968). There seem to be no problems with misidentification or synonomy with this species in the literature.

Distribution: *Andropogon virginicus* is native to the southeastern United States and is spreading from its center there. It has been introduced to Hawai'i as recently as 1932 (Rotar 1968), and to California as recently as 1939 (Robbins 1940). It also extends southward into Mexico and South America (Fernald 1950, Robbins 1940, Rotar 1968, Unknown 1970).

Altitudinally, *A. virginicus* extends from sea level to 1200 m above sea level, at least in Hawai'i (Kartawinata and Mueller-Dombois 1972). It may be found at higher altitudes in other locations, but no records have been published.

This species is typically found on fairly level to rolling terrain. In Illinois it is found on rolling upland (Voight 1959) and on extremely dissected upland (Bazzaz 1968). Of interest here is that Voight found that *A. virginicus* was not invading the more dissected locations of his study area due to erosion. In Hawai'i, *A. virginicus* occurs on undulating and sloping terrain, the slope ranging from level to 45 degrees (Kartawinata and Mueller-Dombois 1972).

Distribution in Hawai'i: "It [broomsedge] occurs at the lower elevations in rather moist, open localities on the islands of Oahu and Hawaii, where it affords a certain amount of palatable forage when young, but soon becomes rather tough and woody ... The distribution in the Hawaiian Islands is rather rapid" (Whitney et al. 1939).

This summation by Whitney et al. (1939) is still applicable today. Although many studies have mentioned *A. virginicus* as a component of the vegetation (Doty and Mueller-Dombois 1966, Kartawinata and Mueller-Dombois 1966, Mueller-Dombois and Fosberg 1974, Parman and Wampler 1977) these studies have been done on O'ahu and Hawai'i, so no literature references to its distribution throughout the state were found. An herbarium search at the Bishop Museum and University of Hawaii revealed specimens only from Hawai'i and O'ahu. A look for broomsedge statewide might provide some interesting data. Herbst (personal communication) who has worked extensively on the grasses in Hawai'i cannot recollect seeing the species on other islands but cautions that this may well be because it is a weed and outside his general interest.

History in Hawai'i: The above quote from Whitney et al. (1939) hints that *A. virginicus* may have been used as a forage species. It is unlikely that it was introduced to Hawai'i for that reason, however, as it is not a very desirable forage plant (Dustman and Shriver 1929). Whitney et al. (1939) and Rotar (1968) both list *A. virginicus* as a species whose exact date of introduction was unknown and instead report the date when it was first collected--1932. These two facts may be evidence that broomsedge was accidentally introduced.

No reference to different dates of introduction to O'ahu and to Hawai'i were found.

Whitney et al. (1939) state that the invasion and spread of *Andropogon virginicus* are rather rapid, while Egler (1939, 1947) and Hosaka (1937) don't record the occurrence of the *A. virginicus* grass community. On both Hawai'i and O'ahu it has spread rapidly since its introduction, until now it is invading disturbed areas in the rain forest and dominating herbaceous and savannah vegetation of the sub-montane zones on Hawai'i (Mueller-Dombois and Fosberg 1974) and is now the most dominant grass cover on the windward side of O'ahu (Kartawinata and Mueller-Dombois 1972).

Chromosome Patterns: The chromosome pattern of *A. virginicus* is typical of the pattern for most species of the tribe Andropogonae. Gould (1956) states that "the basic chromosome number for the majority of the taxa in the Andropogonae is generally considered to be n=10" and that "the general occurrence of polyploidy in the Andropogonae is well known."

From studies of pollen mother cell divisions Gould (1956) confirmed that *A. virginicus* has a chromosome number of n=10, and that it is normally diploid. Gould recognizes the subgenus *Arthrolophis* of the genus *Andropogon* and states "in the United States the subgenus *Arthrolophis* predominantly is represented by *A. virginicus* and its allied species. All apparently closely related New World species of this group are diploids."

Breeding Systems: *A. virginicus* is, like most grasses, wind pollinated (Chapman and Jones 1975). No reference was found as to its ability to self-pollinate or if it has mechanisms to promote cross pollination.

GENECOLOGY

Genecology deals with whether different races of a species complex are found in different locations and whether the races are discretely differentiated or differentiated over a continuum.

The number of varieties of Fernald (1950) which are distinguished by minor morphological differences, may be an indication that *Andropogon virginicus* does have different races in different locations, for these varieties have geographical ranges which fall within the range that Fernald gives for the species. Also, these varieties typically occupy habitats of generally wetter edaphic conditions than those delimited by Fernald for the species. However, it is impossible to tell if Fernald thought of these as ecotypes or not, and there was no indication of reciprocal transplant experiments done with these varieties.

For the related *Andropogon gerardi* Vitman-*A. halli* Hack. complex it was found that plants from the northern Great Plains flowered earlier, were physically shorter, and entered dormancy earlier than plants from the southern Great Plains, when reciprocal transplants were done at Lincoln, Nebraska (MacMillan 1959).

In Georgia, Chapman and Jones (1975) found two ecotypes of *Andropogon virginicus* within 0.75 km of each other, one ecotype from an old field and the other from a nearby granite outcrop. The difference between the sites was wholly edaphic--the outcrop soil was found to be 10-15 cm deep at maximum and the plants were subject to severe water stress, whereas the old field soil was deeper and had greater water retention. Also, the phosphorus content of the old field soil was found to be 3-4 times that of the granite outcrop soil.

No significant morphological or anatomical variation was found; rather the variation was physiological. The plants from the granite outcrop were found to lose water from their leaves at a slower rate and to have a significantly higher rate of acid phosphatase activity than plants from the old field. Thus the outcrop plants were better adapted to water stress conditions and were better able to extract inorganic phosphate from the soil.

The reciprocal transplant experiments from this study yielded the following results: the old field plants were severely stunted when grown in the outcrop soil whereas plants from the outcrop soil grew as well in outcrop soil as in greenhouse soil. Also, when both ecotypes were grown in old field soil there was no difference in growth rates.

Chapman and Jones concluded that *A. virginicus* from the granite outcrop was genetically different from the type found in the nearby old field and that it was indeed a case of ecotypic variation because it was environmentally correlated and was maintained in the face of limited gene flow by differing selective pressures.

Thus, there is ecotypic variation in *A. virginicus* but how widespread it is cannot be determined as yet, at least from looking at the literature.

DEVELOPMENTAL HISTORY

Seed Stage: Seeds of *A. virginicus* are small and wind borne (Keever 1950), with each individual seed weighing on the order of $3x10^{-4}g$ (Golley 1965). Despite their small size, Keever (1950) suspected that the seeds may not be easily transported, which is in accord with the idea that seeds of other *Andropogon* species do not travel long distances (Rice et al. 1960). For North Carolina seeds, Keever determined that seeds would not germinate under any conditions without a period of cold dormancy. While there are a number of factors that can break seed dormancy, it seems highly unlikely that cold treatment is an absolute requirement for germination of broomsedge seeds because of its subtropical range. That is, Kartawinata and Mueller-Dombois (1972) report that *A. virginicus* does come up as seedlings in open areas in Hawai'i under natural conditions, obviously without a cold treatment. However, no other information is available on either dormancy of *A. virginicus* seeds or on other treatments (moisture, aeration, seed-coat breakdown) that would break dormancy. This is not to say that cold treatments are ineffective in promoting seed germination. Indeed, Golley (1965) reported 84 percent germination of broomsedge seeds after a 30 day treatment of stratification at 5°C, compared with 20 percent germination reported by Voight (1959) under field conditions.

However, in North Carolina, Keever (1950) noted that broomsedge seeds in the field germinate at different times throughout the year--some in the spring, some during the summer and some in late fall which suggests that cold treatment may not be the only factor to break seed dormancy.

Seedling Stage: In greenhouse experiments under varying light conditions and watering periods, Keever (1950) found that broomsedge seedlings showed their optimum growth in full sunlight with a seven day period between waterings. Along this line, Kartawinata and Mueller-Dombois (1972) observed that seedlings don't come up under the thick litter of a mature *A. virginicus* stand, but were observed under mature plants in open places where the ground is not covered. In Illinois, Bazzaz (1968) found that in fields further along in succession the broomsedge was generally not found under the canopy of trees. Thus it appears that broomsedge seedlings have a requirement for high amounts of sunlight, i.e. it is shade intolerant. Keever reported a definite chlorosis and reduced growth under reduced light conditions. She also reported that seedlings were fairly drought resistant, with a large percentage being able to survive one to two weeks in full sunlight without watering.

Juvenile Stage: After the seedling stage the survival of broomsedge is greatly enhanced due to its drought resistance. Indeed, Keever found that the survival of broomsedge plants beyond the seedling stage was almost 100 percent in both field and greenhouse conditions. Young plants are generally small and may consist of just one culm. Keever found that broomsedge plants increase in clump circumference in their second year and also that blooming is delayed until their second fall. She gives data of first year plants averaging 5 inches high (but does not include a basal diameter measurement for first year plants), second year plants averaging 40 inches high and 3 inches basal diameter and third year plants averaging 39 inches high with a basal diameter of 10 inches.

Nearly all investigators who reported on the activities of broomsedge in the field reported that between growing seasons, even before it blooms, it enters into a period of partial dormancy when only a central green portion remains active (Wiegert and McGinnis 1975, Golley 1965, Kartawinata and Mueller-Dombois 1972, Mueller-Dombois 1973, Voight 1959). Growth resumes again in the spring, generally accompanied by new shoots arising from the base, resulting in the increase in basal circumference.

Reproductive Stage: As mentioned previously, the fall of the second year of growth is when broomsedge enters the reproductive stage of its life cycle, a pattern repeated annually until the death of the plant. After coming out of winter dormancy, the plant increases in biomass until a peak growth rate is reached in June or July (Voight 1959, Golley 1965, Wiegert and McGinnis 1975). In South Carolina, Golley found a maximum relative growth rate of 0.089 g/g/day in July of 1960, when the leaf area index was also at its peak ($4.9\ m^2/m^2$). Throughout the rest of the summer the growth rate declines until October, when the growth rate increases slightly as a result of flowering (Golley 1965, Wiegert and McGinnis 1975). Golley also indicates that stem and leaf biomass increases until the end of October after which there is a sharp reduction until the next season's growth begins.

Detailed studies that would give root growth rates were too time consuming and gave such variable results that it was investigated little. Golley (1965) found that biomass of roots showed no discernable pattern of fluctuation which could be correlated with the seasonality of the above ground portion of the plant. His data seem to indicate a decrease in standing crop of root during dormancy one year, but subsequent years do not show the same pattern. Furthermore, Crapo and Coleman (1972) found that root respiration was better correlated with soil moisture (and possibly temperature) than with seasonal changes in biomass. This may be an indication that root growth is more or less independent of shoot growth, and that roots undergo fluctuations in activity in response to soil factors more so than in response to factors governing the above ground portions of the plant. However, the biomass of the shoot system does not necessarily reflect the biomass of active tissue in this plant where so much of the aerial portion is dead. Thus, the figures for root/shoot biomass ratios are difficult to obtain.

The distribution of roots under the plants seemed to lend itself to study, however. Most broomsedge roots extended from 1/4 to 3/8 of a meter from the edge of each clump, with few roots being found beyond that distance (Keever 1950). Root mass also increases slightly, but statistically insignificantly, toward the center of broomsedge clumps (Crapo and Coleman 1972). It was also found that 74 percent of all broomsedge roots were located in the upper 10 cm of the soil, with no difference in root mass between 0-5 cm and 5-10 cm depth classes (Crapo and Coleman 1972).

After the second growing season in the life of a broomsedge plant, the plant enters its dormant overwintering stage, but before it does, leaves develop in the basal area which live through the winter. In the spring, when general growth is resumed, these leaves are the first to start growing, with the blades separated from the old sheaths of the previous year. Leaf blades grow from an average width at mid-blade of 2 mm in April to 5 mm in August and range in length from 11 to 48 cm. There was an average of 5.7 leaves per culm (Golley 1965).

Culms are the vegetative propagative units of the broomsedge clump; young plants may be composed of only one culm, while older plants may be composed of 50 or more. Culms begin to grow in the spring in association with the basal leaves and increase greatly throughout the summer up until peak growth, after which they decrease in biomass due to death and drying. The plant then sets seed at or near the top of the culms after which the culm dies and new basal leaves are produced on entering the dormant, overwintering phase (Golley 1965, Dustman and Shriver 1929).

As for the actual flowering of *Andropogon virginicus*, there was no mention of the specifics of microsporogenesis, megasporogenesis, or fertilization. Keever (1950) found that early seeds found under flowering plants in the field in early October were soft and immature, and that firm, viable seeds were not found until the first week in November.

Broomsedge is a copious seed producer, however. Golley (1965) gives data for a 72 g clump of *A. virginicus* that produced 5,500 seeds in a South Carolina old field.

Senescent Stage: Maximum clump diameter is achieved after 7 or 8 years, and this is probably the maximum life-span of a single plant. As previously discussed, the culms of each season's growth die after flowering, and new culms are produced in the following growing season. These dead culms are held in the clump until the entire or a major portion of the clump falls over. The explanation for the death of the plant is that the dead culms held in the clump eventually become so dense that they shade out the basal photosynthetic apparatus and the whole clump dies. In most cases the clump remains standing (dead) for another growing season until it falls over, but it was reported that one dead clump remained standing for three years before it fell (Wiegert and McGinnis 1975, Golley 1965).

ECOLOGICAL RELATIONSHIPS

Climatic Relationships: Since *A. virginicus* has such a wide geographic distribution, occurring from the tropics almost to latitude 49°N, it is found in a wide variety of climatic types. No generalizations can be made about the climate in which it occurs. The length of the growing season seems to be of little importance (as long as a minimum is achieved), whereas light intensity is critical, since *A. virginicus* is a shade intolerant species. It is also rather drought resistant, but seems to do best in areas that have excess soil-moisture during the plant's dormant stage (Bazzaz 1968, Kartawinata and Mueller-Dombois 1972).

Nothing was found in the literature on the qualitative effects of light on broomsedge. While no quantitative details are included by most authors, a number of them make the observation that broomsedge usually gives way to other species under shaded conditions (Kartawinata and Mueller-Dombois 1972, Bazzaz 1968, Keever 1950, Voight 1959). Keever, in greenhouse experiments varying light intensities from full sunlight (6000 ft. C.) to half-sunlight (3000 ft. C.) to quarter sunlight (1500 ft. C.) found that *A. virginicus* did best at 6000 ft. C. and was stunted under the other two light intensities. Golley (1965) in South Carolina found insolation in a broomsedge stand varied from 550 gcal/cm^2/day in May and June to 250 gcal/cm^2/day from November to February. This is identical to insolation data provided by Wiegert and McGinnis (1975), also in South Carolina.

Temperature effects are not discussed much in the literature on *A. virginicus*. At the northern edge of its range it must be somewhat frost resistant. Bazzaz (1968) reports a growing season of 190-210 days in southern Illinois. In January (mean temperature of 2.7°C) *A. virginicus* is dormant and is not killed by freezing temperatures, since it shows vigorous spring growth in this area. In Hawai'i, it rarely freezes below 1,300 m. In the lower elevational ranges the growing season is year-round and this species grows vigorously, but still enters dormancy after flowering (Kartawinata and Mueller-Dombois 1972). Thus, it appears that *A. virginicus* is somewhat indifferent to temperature periodicity, and can endure freezing temperatures. The lower limit and upper limits are not known, but optimum temperature, at which growth is best, seems to be between 20° and 26°C (Bazzaz 1968, Kartawinata and Mueller-Dombois 1972).

A. virginicus seems to do best in humid climatic regimes, even though Keever (1959) determined that it was relatively drought resistant. In southern Illinois, Bazzaz (1968) found that broomsedge was expanding its range in an area that received 1170 to 1220 mm annual precipitation with highest rainfall in March, April and May (110-126 mm) and lowest in September and October (68 and 72 mm respectively). Kartawinata and Mueller-Dombois (1972) found *A. virginicus* as the dominant species in grass communities on the windward side of O'ahu, where rainfall averages more than 100 mm per month for every month of the year. In this area there was an average of ten rainless days per month, with the longest period without rain lasting only nine days. They observed that *A. virginicus* grew best where water was available throughout the year, and was generally not dominant where there was a summer drought period. This observation and Keever's determination that *A. virginicus* is relatively drought resistant must be viewed in the light of competition--i.e. compared to other grasses on O'ahu, especially *Heteropogon*, *A. virginicus* is less drought resistant than compared to other species in North Carolina, where Keever's study was made.

Edaphic Relationships: *A. virginicus* grows on a variety of soil types over its range, but is generally associated with somewhat acidic soils of low fertility.

Golley (1965) found *A. virginicus* growing on a Cahaba sandy loam substrate that had a tillage pan, which few roots penetrated, between 20 and 30 cm deep. Above the pan, in the Ap horizon, the soil was 85 percent sand, 5 percent silt and 10 percent clay and had an organic matter content of 2 percent, whereas Crapo and Coleman (1972) found it growing on the same Cahaba loam with 3.5-4.0 percent organic matter. Bazzaz (1968), in southern Illinois, found *A. virginicus* growing on silt loams over loess parent materials which had fragipans which restricted root penetration. On O'ahu, Kartawinata and Mueller-Dombois (1972) found *A. virginicus* on Lithosols (deeply weathered rock and little soil), Low humic latosols, Humic latosols and Podzolic soils, which are usually greater than 1 m deep, but they also found it on soils only 10-25 cm deep.

Bazzaz (1968) found that on his study area, the fragipans also restricted water penetration such that during the late winter and early spring the upper part of the profile was saturated and runoff was high. This is similar to the situation described by Mueller-Dombois (1974) for O'ahu, where the soils under *A. virginicus* communities were saturated during the winter rains, causing increased runoff. Kartawinata and Mueller-Dombois (1972) found that soils in the windward zone of O'ahu were never below field capacity to a depth of 100 cm and that *A. virginicus* was maintaining its position on these wet soils, even though it was growing with reduced vigor when compared to well drained soils.

A. virginicus seems to have minimal nutrient requirements, as it is associated with soils of low fertility which are typically acidic (Bazzaz 1968, Kartawinata and Mueller-Dombois 1972, Lowance et al. 1975, Peters and Lowance 1974, Rice 1972, Voight 1959). Bazzaz's study area in southern Illinois was low in organic matter, nitrogen and phosphorus, but medium to high in potassium. Lowance et al. in Missouri found *A. virginicus* on soils with less than 25 kg/ha of P_2O_5 and about 100 kg/ha K_2O, while Peters and Lowance found *A. virginicus* as a dominant on soils with 10 kg/ha P_2O_5 and 75-110 kg/ha of K_2O, also in Missouri. Reported average pH measurements for soils under *A. virginicus* ranged from 4.7 (Kartawinata and Mueller-Dombois 1972) to 5.6 (Peters and Lowance 1974). Organic matter ranged from 2.0 percent (Golley 1965) to 4.0 percent (Crapo and Coleman 1972). Keever (1950) from greenhouse experiment results, concluded that *A. virginicus* grew better on soil with organic material, although it is doubtful that a condition of relatively high amounts of organic matter is advantageous to *A. virginicus* in the field (see Response to Fertilization).

Response To Fire: *A. virginicus* is well adapted to fire, and typically increases its range, cover and frequency after a fire. Infrequent burns seem advantageous to broomsedge as they clear the litter and stimulate growth from the periphery of the clumps. The litter clearing also allows new seedlings of broomsedge to become established. Also, *A. virginicus* may have a role in promoting fires since its litter forms a flammable matrix (Kartawinata and Mueller-Dombois 1972, Mueller-Dombois 1973, Parman and Wampler 1977, Voight 1959). On O'ahu, Kartawinata and Mueller-Dombois concluded that many grassy hills in the humid area, now dominated by *A.*

virginicus, were the results of recurrent fires and that after *A. virginicus* was introduced it displaced *Paspalum orbiculare* and *Setaria geniculata* which don't resprout or reseed as well after a fire as broomsedge.

Response to Biotic Factors: There was very little information on the response of broomsedge to biotic factors, especially parasites and pathogens. There was some information on its response to grazing. Voight (1959) found no adverse effects on broomsedge by cattle, while Dustman and Shriver (1929) observed that new growth of broomsedge was protected from grazing by standing dead growth. Wiegert and McGinnis (1975), in looking at grazing by spiders concluded that material removed by grazing on living vegetation (primary biophagy) was relatively unimportant.

Synecological Relationships: Lists of species with which *A. virginicus* is found over its range are inappropriate for the scope of this paper. Let it suffice to say that *A. virginicus* is usually found as a dominant species in open fields and is typically associated with an understory of plants which have been displaced by it, and by herbs and forbs peculiar to the specific area in which the broomsedge is dominant. It is almost never found as a conspicuous understory species in woody communities, presumably because of its shade intolerance. For example, in North Carolina, Keever (1950) found that *A. virginicus* assumed dominance in the third or fourth year following the abandonment of a field. It displaced horseweed (*Leptilon canadense* L.) and aster (*Aster pilosus* Willd.), yet these species remained in the community as isolated plants. In Hawai'i, *A. virginicus* has displaced *Paspalum orbiculare* and *Setaria geniculata*, yet these species are still found in small amounts in broomsedge communities. From published species lists, the understory plants in a broomsedge dominated community differed from North Carolina to Illinois to Hawai'i (Bazzaz 1968, Kartawinata and Mueller-Dombois 1972, Keever 1950). In southern Illinois broomsedge was displaced by *Solidago altissima* under the canopy of trees, much as it is displaced in Hawai'i by *Setaria geniculata* under *Eugenia* (Bazzaz 1968, Kartawinata and Mueller-Dombois 1972). While it does occur in association with trees, it is almost always in parkland or savanna vegetation types, where broomsedge can be exposed to full sunlight.

It should be noted that after dominance is achieved by broomsedge species diversity begins to increase. Golley (1965) found that the number of dominant species (defined as a species having a peak standing crop over 1 g/m^2/yr) increased from 8 to 14 over the three years of his study.

Competitive Ability: *A. virginicus* is uniquely adapted as a weedy invader of abandoned fields. It typically assumes dominance in the third or fourth year following abandonment, and maintains its dominant position for ten or more years, usually until tree cover is sufficient to shade it out.

First of all it produces copious numbers of light, wind-borne seeds, which although they do not travel great distances, allow for rapid increase in numbers of plants (Golley 1965, Keever 1950). In fact, Keever found that broomsedge was delayed in assuming dominance until the third year because until that time the few invaders of the first two years are incapable of producing enough seeds to populate the fields; that is, the spring of the third year is the first time there is an abundance of broomsedge seeds. Secondly, after seedlings become established they have a very high rate of survival due to their relative drought resistance. Keever found that broomsedge increased in density from about 1.0/m^2 in the first year following abandonment to 24.7/m^2 in the third year, when broomsedge became dominant, with almost monthly increases. This is about the same density as found by Golley (1965) in South Carolina. He reported a maximum density of 21.2 clumps/m^2.

Furthermore, its drought resistance and low nutrient requirements allow it to invade areas where other species are weakened by drought or unable to compete because of the low nutrients in the soil (Peters and Lowance 1974, Voight 1959).

The ability of *A. virginicus* to resprout and reseed rapidly following fire also gives it a competitive edge over other species that aren't so adapted, especially in areas where fires and broomsedge are both of recent introduction (Kartawinata and Mueller-Dombois 1968, Voight 1959).

Also, after dominance is achieved, broomsedge litter covers the ground and very few plants, including broomsedge itself, are able to come up under the dense cover, thus allowing broomsedge to maintain its dominance (Kartawinata and Mueller-Dombois 1972, Peters and Lowance 1974, Voight 1959). Rice (1972) found that *A. virginicus* produced an allelopathic substance which significantly inhibited the growth of 5 other Oklahoma species which were dominants in different stages of succession. He also found that sterile extracts of both roots and shoots of *A. virginicus* were inhibitory to two species of *Azotobacter* and to two species of *Rhizobium*, which are all nitrogen-fixing bacteria. Rice concluded that *A. virginicus* keeps soil nitrogen at low levels in this way. Thus, broomsedge is able to maintain dominance through these mechanisms, at least until shading overwhelms it.

That broomsedge is shade intolerant does not seem advantageous in competition, and indeed, broomsedge usually loses dominance in the face of shading and if a closed canopy forms over broomsedge it may eventually disappear (Bazzaz 1968, Kartawinata and Mueller-Dombois 1972).

Also, in the face of a more aggressive species, broomsedge will retreat. For example, Kartawinata and Mueller-Dombois (1972) found that *Dicranopteris* fern mats were advancing into the *Andropogon virginicus* community at the rate of about 0.6 m/yr in the absence of disturbance. Here again however, the ability of broomsedge to come back after fire serves to increase its range since Kartawinata and Mueller-Dombois (1972) found that *Dicranopteris* did not come back after fire and that the broomsedge was invading the area which was occupied by the fern mat before the fire.

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ARTICLES AND NOTES

Page

BOWLER, P. A.: *Ramalinopsis*, a Unique Lichen Genus
Endemic to Hawaii 4
CROFT, L., D. E. HEMMES and J. D. MACNEIL: Pu'ukoholā Plant
Survey............... 81
Cultivating an 'Extinct' Species (J. Obata)........................ 35
DEGENER, O. and I.: Hawaiian Specimens in Leningrad and
Geneva............................. 34
Pink-and-White Shower.......................... 48
Review of C. R. Gunn and J. V. Dennis......... 57
Ecology of the Dryland Forest at Kānepu'u, Island of
Lāna'i (G. E. Spence and S. L. Montgomery).................... 62
Editorial.. 26
Endangered Species in Hawaii (T. K. Tagawa)...................... 7
(C. H. Lamoureux).................... 14
FUNK, E. J.: Lichen Dyes.. 31
Genera *Charpentiera* and *Chamissoa* (Amaranthaceae) Distant
Cousins at Best (S. H. Sohmer)................................ 49
Gunn, C. R. and J. V. Dennis (Review by O. and I. Degener)......... 57
Hawaiian Specimens in Leningrad and Geneva (O. and I. Degener)..... 34
Kaluaa Gulch Revisited (S. H. Sohmer)............................ 23
Kauila (*Alphitonia ponderosa*) of O'ahu (J. Obata)................ 52
KRAJINA, V. J. (Review of D. Mueller-Dombois and H. Ellenberg).... 21
LAMOUREUX, C. H.: Endangered Species in Hawaii.................. 14
Recent Pacific Publications................... 37
Lichen Dyes (E. J. Funk).. 31
Mueller-Dombois, D. and H. Ellenberg (Review by V. J. Krajina).... 21
Names and Notes... 26
OBATA, J.: Cultivating an 'Extinct' Species...................... 35
The Elusive Kauila (*Alphitonia ponderosa*) of O'ahu..... 52
Pink-and-White Shower (O. and I. Degener)......................... 48
Pu'ukoholā Plant Survey (Croft, L. et al.)........................ 81
Ramalinopsis, a Unique Lichen Genus Endemic to
Hawaii (P. A. Bowler).. 4
Recent Pacific Publications (C. H. Lamoureux).................... 37
Recently Completed Theses at UH Manoa............................ 59
Society Business........................ 2, 3, 24, 25, 27, 30, 46, 94
SOHMER, S. H.: Kaluaa Gulch Revisited............................ 23
The Genera *Charpentiera* and *Chamissoa*
(Amaranthaceae) Distant Cousins at Best.......... 49
SPENCE, G. E. and S. L. MONTGOMERY: Ecology of the Dryland
Forest at Kānepu'u, Island
of Lāna'i.................. 62
TAGAWA, T. K.: Endangered Species in Hawaii...................... 7

REVIEWERS OF ARTICLES

appearing in Volume 15 (1976)

Carr, G. D.
Hoe, W. J.
Lamoureux, C. H.
Mueller-Dombois, D.
Stemmermann, R. L.

The editor wishes to express his appreciation to Dr. C. H. Lamoureux for his continued contribution of the series of articles "Recent Pacific Publications."

C. W. Smith
Editor

All views expressed in signed articles are those of their author(s) and do not necessarily reflect opinions or positions of the Society.

So, due to its copious output of seeds, its drought resistance, high rate of post-seedling survival, ability to resprout and reseed after fire and its production of masses of litter which may have allelopathic effects on invaders, as well as its low nutrient requirements, *A. virginicus* is an aggressive competitor on open, unshaded fields.

At the time he published his paper, Rice (1972) had not determined what the substance was that was responsible for eliciting the inhibition of other successional dominants in Oklahoma, but suspected it was either chlorogenic acid, ellogic acid, flavenoids or perhaps o-coumaric acid.

PHYSIOLOGICAL RELATIONSHIPS

Pigment Production: Andropogon virginicus exhibits seasonality in pigment production. Peaks of 2.0 mg chlorophyll a/g leaf tissue and 0.57 mg carotenoids/g leaf tissue occur in April, corresponding with the presence of overwintering leaves. There is also a subsidiary peak in November when the overwintering leaves are formed. In contrast, peaks of 130 mg chlorophyll a/m^2 and 20 mg carotenoids/m^2 occur from July to September at the same time as the peak surface area of the leaves. This means that the overwintering leaves have the highest density of pigments/leaf, while the pigment production for the plant as a whole increases throughout the growing season. Also, the ratio of supporting tissue to photosynthetic tissue was highest from April to July, after which supporting tissue increased while chlorophyll a decreased. In April about 2000 g of tissue supported 1 g of chlorophyll a (Golley 1965).

Photosynthetic Efficiency: Andropogon virginicus is a C_4 (Hatch and Slack type) plant and as such has a relatively high rate of CO_2 fixation and a low rate of photorespiration. Some C_4 plants exhibit a post-illumination burst of CO_2 evolution which has been interpreted as a remnant of photorespiration whereas others, including *A. virginicus*, have no post-illumination CO_2 burst and there is a question as to whether they photorespire at all.

A. virginicus also has reduced grana in the chloroplasts of parenchyma sheath cells, and this has been interpreted as an indication of increased efficiency in photosynthesis--i.e. *A. virginicus* produces malate as the first product of CO_2 fixation and the decarboxylation of malate at the start of respiration generates $NADPH_2$, which may eliminate the need for a photoreduction system in parenchyma sheath cells and thus explain the reduced grana (Brown and Gracen 1972).

Net production determined by the harvest method gave a figure of 650 g/m^2 in a nearly pure broomsedge stand and decreased as more herbs came into the community to 552 g/m^2 of which 275 g/m^2 was contributed by broomsedge. When measured by the CO_2 evolution method, net production was found to be 420 g/m^2. In both these cases peak production occurred in July at about the same time as the surface area of the leaves reached its maximum. Thus, net productivity reached 5.1 g/m^2/day in July, when the leaf area index reached 4.9 m^2/m^2 (Golley 1965). Golley compared this production to that for crop species and found that the broomsedge community falls far short of the theoretical optimum production calculated from the light input. Golley concluded that the discrepancy was due to broomsedge morphology giving it insiffucient light interception capacity because of shading of leaves by standing dead shoots and because of the typically 40° angle of the leaf blades.

Thus, while *A. virginicus* is equipped for efficient photosynthesis, its peculiar growth form does not allow it to be as productive as other, particularly crop plants.

Respiration: *A. virginicus* shows no evidence of photorespiration. *A. virginicus* shows increased respiration with increased ambient air temperature. Night respiration calculated from measurement of CO_2 evolution was 375 g/m^2. Also, respiration increased during the growing season and surpassed net production in August and September. This is correlated with the ratio of photosynthetic tissue to supporting tissue--i.e. when chlorophyll/g was high, net production exceeded respiration, but as the ratio of photosynthetic to supporting tissue declined over the growing season, respiration increased while net production decreased (Golley 1965).

Other Chemical Constituents: Living broomsedge (green shoots and roots together) contained about 40 percent hemicellulose, 30 percent alpha cellulose and 20 to 25 percent lignin. Lignin and cellulose increased during the dormant period, and also at the end of the growing season (Golley 1965).

Crude protein ranged from a low of about 4 percent in May to a high of 13 percent in June, whereas crude fiber was high in May at 40 percent and low in June at 28 percent, but increased to 33 percent by October. Ash was low in May at 3.5 percent and high in June at 8 percent (Dustman and Shriver 1929). Crude analysis of protein by the Kjeldahl method produced slightly lower values, 9 percent crude nitrogen in May declining to about 3 percent in late fall (Voight 1959).

ECONOMIC VALUE

Forage Value: The forage value of *Andropogon virginicus* is questionable. Without mowing, animals are discouraged from grazing on it because the young leaves are protected by the old dead standing growth. With mowing, cattle and sheep were found to graze freely on broomsedge during its early growth, but later in the season, when fiber content had increased and the leaves had toughened, the animals avoided it. When blooming occurs and the protein content of the shoots increases somewhat, it is utilized a little more by grazing animals (Dustman and Shriver 1929, Voight 1959). Voight found consumption in April and May (the period of heaviest utilization) to be 0.20 tons/acre.

Watershed Protection Value: Because *A. virginicus* enters into dormancy during winter months, in areas where winter precipitation is the greatest input to soil water, it is of questionable value as watershed vegetation cover. That is, depending on the overall climate of the region and the amount of water present in the soil at the beginning of the period of winter precipitation, the inability of broomsedge to transpire rapidly because it is in dormancy may, in fact, increase erosion rather than reduce it.

Bazzaz (1968) found that *A. virginicus* did poorly on eroded or rapidly eroding sites. In his study area there were fragipans and during winter the upper horizon of the soil was always saturated and increased runoff occurred. Erosion was severe in this area, however, and there were exposed areas of loess parent material where erosion was rapid. Bazzaz observed that the loss of soil was much higher from the exposed sites than from sites with old field plant cover.

In Hawai'i, Mueller-Dombois (1974) found that because of the habit of winter dormancy and the production of thick litter by *A. virginicus*, effective transpiration and even soil evaporation were being prevented. During winter rains then, the soil, already saturated, was unable to take up any more water, and *Andropogon virginicus*, being dormant, was doing little to alleviate the situation. These factors were causing increased runoff and silting away of the topsoil.

Of course, both Bazzaz and Mueller-Dombois are probably correct, with the difference in watershed protection being due to the soil difference. That is, Bazzaz was dealing with moderately to well-drained silt loams, where roots would function to hold the soils together better in the face of erosion, while Mueller-Dombois was dealing with tropical clay, where the prevention of transpiration and evaporation would increase soil water beyond what the soil could possibly hold and consequently increase runoff and erosion.

So, the value of *A. virginicus* as a watershed protecting agent is not a constant for the species, but depends on the soil characteristics where it is found.

Potential for Revegetation: *A. virginicus* could certainly revegetate an area fairly efficiently after it was established, but there are more desirable species with which to revegetate an area.

Response to Fertilization: In field situations fertilization of a broomsedge-dominated area results in other species being encouraged whereas broomsedge is excluded. For example, Peters and Lowance (1972) fertilized a broomsedge field with 112 kg/ha phosphate, 112 kg/ha potash, 134 kg/ha nitrogen and 6.7 metric tons/ha of lime. They then drilled "Kentucky 31" tall festcue into the area and after four years the *A. virginicus* had disappeared. Thus, by increasing soil fertility and encouraging a competing grass they eliminated *A. virginicus*.

Control Methods: The previous section on response to fertilization gives an example of one method to control broomsedge. Other herbicidal methods are also available.

Lowance et al. (1975) found that monosodium methanearsonate (MSMA) and disodium methanearsonate (DMSA) killed 27 to 90 percent of the *A. virginicus* plants when applied at a rate of 1.1 to 6.7 kg/ha in July. While this did not effect other plants in the area, broomsedge became rapidly re-established from seed. This re-establishment could possibly be discouraged by increasing the density of other grass species.

Williams and Wiegert (1971) treated a field with napthalene and found that napthalene killed all broomsedge plants 30 to 60 days after the first application and that subsequent seedlings survived only one or two weeks. Also, ten months after the last napthalene application few seedlings were growing in treated plots whereas the control plots had many seedlings. They concluded that napthalene treatments can completely eliminate old field species, particularly broomsedge, from treated areas.

CONCLUSION

Andropogon virginicus L. is a weedy species well adapted to invasion and dominance on soils of low fertility. It is found over a large geographical and climatic range which adds difficulty in making generalized statements on its ecological relationships.

Most studies on this species have been done in the eastern half of the United States, where it occurs as a native species. Since this area is a temperate climatic area, and since most studies have been done where *A. virginicus* occurs on sandy or sandy loam soils, it is almost impossible to predict, on the basis of existing studies, the behavior of this species in the tropical climate and on the tropical clay soils of Hawai'i, especially since it is a recently introduced species.

The non-adaptive winter dormancy behavior of *A. virginicus* in Hawai'i is particularly perplexing in this regard, as in the region where it is native this behavior is considered adaptive and thus has not really been investigated.

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ENDANGERED HAWAIIAN PLANTS

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In the autumn of 1765, the famous American naturalists John and William Bartram discovered, as William later wrote of it: "... a flowering tree, of the first order for beauty and fragrance of blossoms." Plants were placed in the botanical garden the elder Bartram had established near Philadelphia. It proved to be a close relative of the *Camellia* and was named *Franklinia alatamaha* to honor the Bartrams' friend, Benjamin Franklin, and to denote the place of discovery, along the Altamaha River near Fort Barrington, Georgia. Although he explored the southeastern U.S. extensively, William Bartram wrote in 1773 that he: "... never saw this beautiful tree growing wild but in one spot on the Altamaha about 30 miles from the sea coast, neither has any other person that I know of ever seen or heard of it." And later (1778): "We never saw it grow in any other place, nor have I ever since seen it growing wild, in all my travels, from Pennsylvania to Point Coupé, on the banks of the Mississippi, which must be allowed a very singular and unaccountable circumstance; at this place there are two or three acres of ground where it grows plentifully.

By 1784, at least, the Bartram sons had offered the plant for sale in Europe. It was later listed by their kinsmen, Humphery and Moses Marshall, in their "Catalog of American Plants." Because of the beauty and fragrance of its flowers, the *Franklinia* was in great demand in horticulture. The Marshalls received orders for hundreds of plants from London Nurserymen, including such as the one from Grimwood, Hudson and Barrit of London requesting that they send "as many as you can" of *Franklinia*. It is known that Moses Marshall visited the Altamaha in 1790 ostensibly to fill commercial orders. It also is known that the plant was last seen in the wild in 1803. What role the Marshalls and the London nurserymen had in the decimation of the wild population is not known, but it can be presumed to have been great. It is ironic that the Bartrams, by cultivating *Franklinia* in their Garden not only saved the genus from extinction, but also, by drawing attention to its ornamental value, may have caused its demise in the wild.

The *Franklinia* was the first plant species native to North America known to have become extinct in the wild. Today, 100 flowering plants in the continental U.S. may be extinct. No one knows how many kinds of lower plants have been destroyed.

REASONS FOR PLANTS BECOMING ENDANGERED

Commercial exploitation is a persistent problem. Nearly a third of our native cacti are candidates for the endangered species list, many because of over exploitation by hobbyists and commercial concerns. Yet cacti still are collected literally by the truckloads for commercial nurseries. The rarest species are in the greatest demand and thus command the highest prices; the high prices encourage dealers to seek and collect those species; the resulting decrease in wild, reproducing populations make the species still rarer--and so the cycle continues. The collecting and growing of cacti and succulents is a popular pastime that has attracted a great number of people throughout the world. The impact of commercial collectors on the environment has been enormous. Although the cactus and succulent societies have encouraged their members to grow the rare species directly from seed, their efforts have not been entirely successful. Regulations published by the U. S. Fish and Wildlife Service in the June 24, 1977, *Federal Register* are designed to regulate commerce in such species through a permit system.

Carnivorous plants and orchids are also very popular horticultural items because of their beauty, novelty and mystique. There have been recent documented cases of commercial dealers collecting entire populations of rare carnivorous plants, and trees have been completely stripped of their epiphytic orchids in such remote areas as the jungles of New Guinea. The sad part is that many of these plants die before they reach the market, and even more are inadvertently killed by the amateur horticulturists who attempt to grow them. International trade in groups such as orchids and tree ferns is now regulated by permits under rules published by the U. S. Fish and Wildlife Service in the February 22, 1977, *Federal Register*.

Commercial exploitation, however, does not eclipse the more basic problems caused by radical environmental changes. The destruction of habitats is probably the most serious of these. Plant habitats are continuously being altered or destroyed by man and his activities--over grazing by domestic animals, drainage of swamps, marshes and bogs, strip mining, stream channelization, irrigation, flooding, destructive fires or the prevention of natural fires, construction, the release of pollutants into the environment, and the accidental or intentional introduction of predators, diseases and aggressive weeds.

A recent newspaper article described the effects of industrial pollutants on the flora and fauna of New York's mountain lakes. The pollutants--chlorides and nitric and sulphuric oxides--are spewed from factory smoke stacks and converted to acids in the atmosphere. Eventually they are washed from the sky by rain and snow. One, nitric acid, has increased in concentration fourfold in New York State over the past ten years. The resulting acidic rains have killed fish, frogs, salamanders, microscopic animals and plants. Studies by Cornell University have concluded that more than half of the mountain lakes of New York State are now highly acidic and that the fish life in 90 percent of these has been destroyed.

The use of biocides has directly and indirectly affected plant populations. Fertilizers and herbicides pollute the air, water and soil, eliminating or changing populations of plant species. Insecticides used to control agricultural pests indiscriminately kill both harmful and beneficial insects. The plant pollinators and the predators of insects injurious to plants are destroyed along with those few insects that attack commercial crops.

The balance of nature is delicate; the web of life poorly understood. An act that may seem beneficial or of little consequence can have unknown long-range ramifications on the environment. The environmental consequences on each of the activities of man mentioned above could be the subject of a separate article, but the brief examples used here give some insight into the causes of rarity.

In 1975, the Smithsonian Institution, acting upon an order of the Congress, published a list of candidate endangered and threatened plant species of the United States. The list includes about 10 percent of all higher plants in the United States. Some 1,700 taxa were later included on a revised list of proposed endangered species published by the U. S. Fish and Wildlife Service in the June 16, 1976, *Federal Register*. About fifty percent of the plants on the latter list are native to the Hawaiian Islands. The rest are in 45 other States.

HAWAIIAN PLANTS

Why is Hawai'i so exceptional? The answer can be summarized by a single word: isolation. Hawai'i is at least 2,000 miles from the nearest high island or continental land mass. It may seem almost impossible that a viable seed would ever find its way to such a small, isolated region of the vast Pacific, but approximately 265 species of flowering plants became established out of the unknown number that arrived but failed to survive. These 265 founders can account for all the 2,750 or so species, subspecies and varieties of flowering plants native to Hawai'i.

When a plant species arrives on an island, the environment is usually without natural predators and competitors. Until balance can be restored, a successful arrival usually can be expected to produce enormous numbers of offspring which move into all available space. Often some are able to survive in environments totally alien to their ancestors. When their numbers are brought into check, small isolated colonies sometimes are found. With their limited gene pool and through the accumulation of the expected changes in their genetic makeup, they soon become different enough to be recognized as new varieties, subspecies or species. Bizarre forms at times are maintained simply because there is nothing more successful or efficient competing with them.

Isolation has made Hawai'i a workshop for evolution; it is recognized throughout the scientific world for this. Hawaiian flora and fauna, and the knowledge to be gained through the study of them, is an important part of mankind's heritage. A few shortsighted individuals can easily destroy that which belongs to the world.

Isolation has prevented the natural introduction and colonization by grazing, browsing, trampling animals. Ninety-seven percent of our native flowering plants evolved here; they did not develop defenses against herbivores, as they did not need them. Few have prickles, poisons and deep root systems and few can withstand the attacks of the animals man later introduced, or for that matter, man himself.

About 1500 years ago, Polynesian explorers arrived on the pristine shores of these islands. They burned and cleared land for their crops and villages; pigs and rats were introduced, and some of the plants they brought with them began to compete with the native ones for available space. Undoubtedly some plant species became extinct, but there is no way to know how many. The mass destruction of native plants began with the introduction of goats and English pigs by Captain James Cook in 1778. Fifteen years later Vancouver, an English sea captain, brought sheep and cattle. Goats have been introduced to many islands throughout the world to provide a source of meat for passing ships. They probably have caused more destruction than any other creature save man. A kapu placed on cattle allowed the build-up of enormous herds until their destruction was so great that man was forced to contain or destroy them. Weedy species followed the animals taking advantage of the disturbance they made.

The land management policies of large estates, government agencies and speculators and developers have made a shamble of the islands with the result being that more than two-thirds of the perhaps extinct plants in the U.S. are of Hawaiian origin. Hawaii's natural resources, which could be a source of pride to the State, have become its shame; more so for those with the power and ability to have prevented it.

What has been done cannot be undone: there is no way that a species can be recreated or that a balanced association of plants and animals in an ecosystem can be restored to their original state, once disturbed. What man can do is attempt to save what is left. It is too late for many species but there is still enough time to conserve others if we act now.

WHAT CAN BE DONE?

Plants can be brought into cultivation. This is best done in arboreta and botanical gardens; plants for private gardens should be obtained from those already in cultivation. Mass wild collections of plants or propagules for the horticultural trade can result in the destruction of that species in the wild--remember the *Franklinia*. Cultivation, however, is probably the least satisfactory way to maintain a species. The small number of plants which can be placed under cultivation will result in a very limited sampling of the available gene pool. Perhaps some of the most valuable genetic factors will be lost. The plants are, of necessity, "grown out of context." The natural populations, associations and environments are lacking. The different environment and the different selective forces at play will eventually cause a change in the species. Another factor to be considered here in Hawai'i is our general lack of genetic barriers between species or, for that matter, certain genera. The isolating barriers contributing to speciation in the Hawaiian flora were primarily geographical. Removing the geographical barriers, as we do when we develop a collection of native plants in a botanical garden, may result in the formation of an artificially induced hybrid swarm rather than in the preservation of a rare native plant. Thus, care should be taken to preserve and maintain the integrity of the taxa involved. A hybrid may be more vigorous and attractive than either parent, but it should not be maintained at the expense of the natural parental lines. It isn't that rare and endangered species should not be brought into cultivation. They should be, but only as a back-up safeguard in event of the loss of those in the wild.

The only satisfactory way to preserve a plant is to conserve its environment. This cannot be done by building a fence around a single plant or around a five acre plot of trees. It has been tried in the past and is not particularly successful. It tends to slow down rather than prevent eventual extinction caused by man. Large tracts of land, with adequate buffer zones, sampling the different ecosystems should be set aside on each of the islands. Roads and trails should not be developed into these areas as this would merely facilitate the ingression of aggressive weedy species and casual tourists. Hunting should be encouraged to control the existing populations of exotic fauna.

Several states have passed laws which encourage private landowners to preserve and protect natural areas and key wildlife areas. Under these conservation easements, the property owner voluntarily gives up all future rights--his, his heirs or future buyers--to develop or to change the traditional use of the land. In return the economic value of the land may be reduced to perhaps one-tenth of its present market value. The difference is a permanent deleted value and becomes a contribution to a charitable organization, as Nature Conservancy for example, thus giving the landowner an enormous federal income tax deduction, lower property taxes and reduced inheritance taxes for heirs. Perhaps a law of this sort would induce some large landowners in Hawai'i to forego development of certain natural areas. They would not be compelled to develop an area in order to meet the rising cost of taxes.

Hawai'i has a system through which natural areas can be set aside for conservation purposes. Act 139, which took effect June 22, 1970, established a commission to study and recommend areas to be included in the Hawai'i Natural Areas Reserve System. These areas would be set aside for preservation. Two reserves have been established and, at present, the commissioners are studying other potential sites. The flora and fauna of the sites are protected by law and are to remain as relatively unmodified as possible.

The U. S. Congress passed acts for the conservation of endangered species in 1969, but they were for the conservation of animals only. The Endangered Species Act of 1973, a revision of the earlier act, rectified this omission and specified that protection should be provided for endangered and threatened species of fish, wildlife and plants. The act defines endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range" while a threatened species is one "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." A species can be considered threatened or endangered if any natural or man-made factor is affecting its continued existence. This may consist of depletion of population due to disease, predation, or overuse for commercial, sporting, scientific or educational purposes. Or it may consist of destruction or modification of its habitat or range.

The purposes of the Endangered Species Act are: (1) to conserve the ecosystems upon which threatened and endangered species depend, (2) to provide a program for the conservation of threatened and endangered species, and (3) to insure that the U. S. upholds its part of certain international treaties and conventions to which it is a party.

In the 1973 act, the Congress directed the Smithsonian Institution to prepare and submit a review of threatened and endangered plant species within a year. The task was officially headed by Dr. Edward Ayensu, then chairman of the Smithsonian's Botany department. Under his direction, Dr. Robert DeFillips and two assistants compiled a list which was published in 1975 as House Document No. 94-51. It was accepted under the Act in a notice of review published by the U. S. Fish and Wildlife Service in the July 1, 1975, *Federal Register*. The Hawaiian portion is a modified extraction from a more comprehensive study by Ray Fosberg and Derral Herbst with the aid of many collaborators.

To summarize the list:

Plant Species

	Continental United States (including Alaska)	Hawai'i
Endangered	761	639
Threatened	1,238	194
Extinct	100	255
Total	2,099	1,088

On June 16, 1976, the U. S. Fish and Wildlife Service published in the *Federal Register* a proposal to list some 1700 plants as endangered. This list consisted primarily of the plants recommended as endangered by the Smithsonian; 895 are native to Hawai'i.

On August 11, 1977, four plants from San Clemente Island, California, were listed. These four are the only species of American plants that have come under the protection of the Act to date. It is estimated that it will take a minimum of 36 professional man-days to legally list a single plant or animal species. The staff at the Department of Interior, U. S. Fish and Wildlife Service, which is responsible for such things, is woefully small for the task it has been given. It has been estimated, not too much tongue-in-cheek, that the Department of Interior, working at its present rate, will require about 6,000 years to list all the plant and animal species in the world that presently need protection by the Endangered Species Act.

Section 7 of the Endangered Species Act states that "all Federal departments and agencies shall ... utilize their authorities ... by carrying out programs for the conservation of endangered species and threatened species ... and ... insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of ... endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical." The potential effect of this section upon the acitvities of government agencies, both Federal and State, is enormous. And the effect is already being felt. Witness the Corps of Engineers Dickey-Lincoln Dam project in Maine where a relative of the snapdragon, once presumed extinct, is one of the factors which may cause the $600 million hydroelectric project to be abandoned.

VALUE OF ENDANGERED SPECIES

Of what value are endangered species? Are they worth the money and effort required to protect them and their habitat?

Extinction is a natural process, but it has been speeded up by man and his activities. Today 100 kinds of flowering plants in the continental United States may be extinct. Beginning with the *Franklinia*, that averages out to approximately one every 1 3/4 years. In Hawai'i, the average is probably closer to one every 9 months. While the comparison may not be entirely valid, the natural extinction rate of the dinosaurs is believed to have been something like one every 1,000 years.

As the title of a recent book of the New York Botanical Garden states, "Extinction is Forever," there is no way that a species and its natural diversity once lost can be restored.

The key word is "diversity." The diversity of a natural gene pool can make many contributions to our well-being. Selection and plant breeding, using the diverse genetic reservoirs of the wild relatives of our cultivated plants may produce a disease-resistant tomato for the truck farmer; a tall, straight, fast-growing tree for the timber industry; or a new drug for the pharmacologist. With the extinction of a species, the source material for a new medicine, potential food, beverage, pesticide, ornamental or industrial product may be lost. And don't forget aesthetics! Much of the beauty of our world is due to its diversity. As Emerson so aptly phrased it: "... if eyes were made for seeing, then beauty is its own excuse for being."

MINUTES OF THE REGULAR MEETING OF DECEMBER 6, 1976

The meeting was called to order by the President, Dr. Gerald Carr, at 7:31 p.m. There were 25 members and 12 guests in attendance. The minutes of the previous meeting were read by the Secretary, Evangeline Funk.

Dr. Lamoureux presented the 1976 Annual Report of the Treasurer and distributed copies of it. Evangeline Funk presented the Secretary's Annual Report.

In the absence of the Nominating Committee, Dr. Carr announced the slate of officers for 1977. Those nominated were:

President - Ted Green
Vice-President - Lani Stemmermann
Secretary - Karen Shigematsu
Treasurer - Dr. Charles Lamoureux
Directors - Winona Char and Dr. Gerald Carr

A motion was made and unanimously approved to accept the nominees.

Dr. Lamoureux introduced a resolution to authorize withdrawals from the Society's savings accounts in the names of the President and Treasurer. The resolution was approved. Dr. Lamoureux introduced a second resolution to allow withdrawals from the Marie Neal Memorial Account in the names of the President and Treasurer. The resolution was similarly adopted.

Steve Montgomery asked for a response by the Society to the feral sheep control program on Mauna Kea. Discussion followed, and a motion was approved to have Mr. Montgomery draft a letter, which affirms the Society's position in favor of a sheep control program and which would be sent to the executive committee for approval.

Another motion was approved to draft a letter of support for the conservation programs of the President of Costa Rica. The letter is to be drafted by Dr. Mueller-Dombois.

Dr. Carr announced that a letter was received concerning the Science Fair. This led to a discussion about appropriate awards for deserving projects, and a motion was passed to allow the Science Fair Committee to decide on the awards.

Several announcements were then made: Dana Peterson invited the Society to attend a slide show presentation of the Manawainui Research Project. Second, it was suggested that a Hawaii chapter of the Western Society of Naturalists could be formed. Interested persons may contact Mr. Manhoff or other members for more information. Third, Dr. Warner invited the Society to the Waimanalo plant science learning facility. Dr. Conant then announced the upcoming Audubon Society meeting.

The program was turned over to Dr. Sheila Conant who introduced Lani Stemmermann as the speaker for the Plant of the Month. She presented a discussion on sandalwood. The speaker for the evening, outgoing-President Dr. Carr, was introduced. His topic was "Ohikilolo or Bust: the true story of how a biosystematists fell for Hawaii," which was a talk about biosystematics, the Hawaiian tarweeds, and other native plants.

The meeting was adjourned at 9:25 p.m.

MINUTES OF THE REGULAR MEETING OF JANUARY 3, 1977

The meeting was called to order at 7:30 p.m. by President Ted Green. There were 20 members and 6 guests in attendance. The minutes of the previous meeting were read and approved.

Vice-President Lani Stemmermann presented the Auditor's report that the Society's accounts are in satisfactory order.

Ted Green reported in "Old Business" that the Society will be participating in the Science Fair; a letter of commendation had been sent to the President of Costa Rica for his conservation programs; and another letter had been sent to the Department of Land and Natural Resources in support of the feral sheep control program on Mauna Kea.

In the absence of the Treasurer, Lani Stemmermann presented the Treasurer's Report. This was followed by an announcement by President Green that, when appropriate, issues discussed in the executive board meeting would be presented at the Society's meetings.

The program was turned over to the Vice-President, who announced that Dr. Ornduff would be in Hawai'i in February. Then Winona Char, speaker for "Plant of the Month," presented a discussion on *Sesbania tomentosa*, an endemic legume.

Following this, Vice-President Stemmermann announced that February would be plant donation month.

In other new business, Mr. Bush noted that one of the plants growing on the University of Hawaii campus is a scarce Guatemalan endemic, *Croton eluterioides* Lotsy (Euphorbiaceae). Identification of the plant was done by Mr. Alan Redcliffe-Smith of Kew Gardens. Also, a suggestion was made by another member that preserved natural areas should be educational also. For example, natural botanic gardens could be included within these preserved areas.

Continuing with the program, the speaker for the evening, Dr. Clifford Smith, was introduced. His topic was "Hawaii's National Parks." Following this presentation, the meeting was adjourned at 9:10 p.m.

MEMBERSHIP DUES 1978

Article VII of the Hawaiian Botanical Society Constitution (as amended on 4 March, 1974) is brought to members attention:

Section 1. The dues for life membership shall be one hundred dollars ($100.00).

Section 2. The annual dues of active members shall be five dollars ($5.00); the active dues for families shall be seven dollars and fifty cents ($7.50); the annual dues of active members who are duly registered students in a *bona fide* educational institution of higher learning shall be two dollars ($2.00); the annual dues of active junior members in elementary, intermediate, or high school shall be one dollar ($1.00). Annual dues shall be payable on December 1 or upon subsequent request of the Treasurer. Any new member paying his first year's dues between September 1 and November 30 shall be considered a paid-up member throughout the subsequent Society year. Only members in good standing shall be eligible to vote on any question brought before the Society.

Section 3. Honorary Members shall be exempt from payment of dues.

Section 4. Any member in arrear of dues six months after the start of the Society year, provided the Treasurer shall have sent him a second notice of dues, may be dropped from the rolls at the discretion of the Executive Board upon recommendation of the Treasurer.

Section 5. Special cases for reduction or remission of dues not included in the foregoing provisions may be decided by the Society at any regular meeting.

Please submit your dues to the Treasurer, Dr. Charles H. Lamoureux, c/o The Department of Botany, The University of Hawaii, 3190 Maile Way, Honolulu, Hawaii 96822 U.S.A.

NEWSLETTER
HAWAIIAN BOTANICAL SOCIETY
C/O DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII
HONOLULU, HAWAII 96822

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Contents

VOLUME 16 NUMBER 3/4 JUNE/OCTOBER 1977

DEVELOPMENT OF EMERGENT VEGETATION IN A TROPICAL MARSH (KAWAINUI, O'AHU)
by Linda L. Smith 37

THE KALAPANA EXTENSION OF HAWAII VOLCANOES NATIONAL PARK: ITS VARIETY, VEGETATION, AND VALUE
by Frederick R. Warshauer 57

BRIEF REPORTS AND NOTES

SOCIETY BUSINESS...34,35,36; *Palmer* - REPORT OF THE NATIVE PLANT COMMITTEE...60; LETTER TO THE EDITOR ...63; EDITOR'S NOTE...63.

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Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

MINUTES OF THE JOINT MEETING WITH THE PACIFIC TROPICAL BOTANICAL GARDEN FEBRUARY 7, 1977

The meeting was called to order at 7:30 p.m. by the President, Mr. Ted Green. There were 70 persons in attendance. The minutes of the previous meeting were made available in written form.

Ted Green reported that an invitation to the Presidential Inauguration had been received, but respectfully declined. Also, the President of Costa Rica sent a letter to thank the Society for a previous letter in which he was commended for his conservation programs. This was followed by discussion of a request from Dr. Dan Palmer for $1000 from the Marie Neal Trust Fund to be used for a status report on rare and endangered taxa. A motion was approved to recommend to the Trustees of the Fund to allow $1000 for this purpose.

Announcements were made for the Audubon Society field trip to Haiku Valley in February. Also, Faith Roelofs invited the public to the Makiki Community Association meetings on Monday evenings.

Then the Treasurer's report was presented. The program was turned over to the Vice-President, Ms. Lani Stemmermann, who introduced Dr. Carr, whose plant of the month was *Capparis sandwichiana*. Dr. Theobald, Director of the Pacific Tropical Botanical Garden, introduced the speaker for the evening, Dr. Robert Ornduff, whose topic was "To the High Atlas: Plant Hunting in Morocco." Following this presentation, the meeting was adjourned at 8:45 p.m.

Karen E. Shigematsu, Secretary

MINUTES OF THE REGULAR MEETING MARCH 7, 1977

The meeting was called to order at 7:35 p.m. by the President, Mr. Ted Green. There were about 60 members and guests in attendance. The minutes of the previous meeting were read and approved.

Mr. Green informed the Society of correspondence from Dr. Gressitt. The letter requested a donation from the Marie Neal Fund to the Wau Ecology Institute. In the discussion that followed Ms. Krauss said that she favored the donation. However, questions were raised about a previous donation to the Institute and whether it was actually paid. It was suggested that previous donations should be followed up. Dr. Lamoureux, the Treasurer, said that he would check the records, but that at this time, he is against a donation since $1000 was just recently given for studying native Hawaiian plants. The proposal was held over until the next meeting.

In New Business, the upcoming Botanical Society meeting, with Bill Magruder as speaker, was announced. Also, Betsy Gagné's journals were made available to the Society.

The program was then turned over to the Vice-President, Ms. Lani Stemmermann, who introduced Dr. Herbst. He spoke about the endangered native plants at Barber's Point and the proposed deep draft harbor there. In connection with endangered species, Frank Howarth announced an important hearing on March 8 for House Bill 1078.

The Vice-President then turned the program over to Dr. Lamoureux who introduced Dr. Edward Ayensu. His topic was "Travels in China." Following this presentation, the meeting was adjourned at 9:00 p.m.

Karen K. Shigematsu, Secretary

MINUTES OF THE REGULAR MEETING APRIL 4, 1977

The meeting was called to order at 7:40 p.m. by President Ted Green. There were 15 members and 8 guests in attendance.

On behalf of the Society, Drs. N. P. Kefford and C. W. Smith judged the research projects presented at the Hawaiian Science and Engineering Fair. In the senior division the award went to Ms. Gale N. Uradomo, Aiea High School. The intermediate division award went to Mr. Daniel Adachi, St. Patrick's School. Both winners received a copy of the republished edition of J. F. Rock's *The Indigenous Trees of the Hawaiian Islands*.

In New Business, Ted Green expressed concern over the spread of *Wedelia* which has escaped into the native ecosystems from cultivation. Then Dr. Palmer talked about *Pteralyxia*, the plant of the month.

The program was turned over to Ms. Evangeline Funk who introduced Mr. Bill Magruder, whose topic was "Photographs of Hawaiian Algae."

After a question-and-answer period, the meeting adjourned at 8:30 p.m.

Karen E. Shigematsu, Secretary

MINUTES OF THE REGULAR MEETING OF MAY 2, 1977

The President and Secretary were not able to attend the meeting because of other commitments. The Vice-President, Ms. Lani Stemmermann substituted for President Ted Green and called the meeting to order at 7:40 p.m. There were 22 members and 19 guests in attendance.

The featured plant of the month was *Isodendrion*. Dr. Lamoureux spoke about this endemic genus.

Then Botanical Society Director, Ms. Winona Char, substituting for the Secretary, read the minutes of the previous meeting which were then approved as read.

Ms. Stemmermann read a thank-you letter from Gail Uradomo, who was one of the Science Fair winners.

Following this, members in attendance shared information on their current research. Dan Palmer talked about rare and endangered plants, and Joyce Davis, who is employed by the Society, reported the status of her herbarium work on rare and endangered species.

Lani Stemmermann announced that the State Legislature has passed a bill to fund the control of *Clidemia hirta*.

The speaker for the evening, Ron Hurov, was introduced. His topic was "Plant Collecting Around the Tropics."

Winona P. Char for Karen Shigematsu

MINUTES OF THE REGULAR MEETING JUNE 6, 1977

The meeting was called to order at 7:30 p.m. Forty-five members and guests were present. The minutes of the previous meeting were read and approved.

The Society was informed that a letter was received from the University of Nebraska. This letter requested seeds of native plants, such as koa, ohelo, or mamaki, which will be used to start a native Hawaiian plant display.

Following this, a discussion was held on the convention on International Trade in Endangered Species of Wild Fauna and Flora. If the new law is put into effect, its restrictions on the import and export of certain plants will have strong ramifications.

Then, in the Plant of the Month section of the meeting, Dr. Carr spoke about a new undescribed species of *Dubautia*.

Following the presentation on *Dubautia*, Mr. Art Whistler of the Botany Department, University of Hawaii at Manoa, was introduced. His topic was "Samoa's Scenic Silisili Summit--Botany of a Montane Volcanic Wilderness."

The meeting was adjourned at 8:45 p.m.

Karen E. Shigematsu, Secretary

DEVELOPMENT OF EMERGENT VEGETATION IN A TROPICAL MARSH (KAWAINUI, O'AHU)*

Linda L. Smith
Department of Botany
University of Hawaii at Manoa
Honolulu, Hawaii 96822

Introduction

This study was undertaken to determine the effect management of Kawainui Marsh has had on the present distribution and occurrence of plant species. Part of the area is an abandoned Hawaiian fishpond. The remainder has been in cultivation at various times. Water levels have been manipulated until recently.

Marsh Development

One of the processes associated with marsh development is terrestrialization of lakes into bogs and ultimately marsh meadows or forests (Tansley 1953, Russell 1942, Dansereau and Segadas-Vianna 1952). Accumulation of mineral soils may approach the water surface. Or the establishment of floating mats of vegetation may create a substratum for the colonization of terrestrial plants or facultative wetland plants, while providing a matrix which traps water-borne sediments.

Penfound and Earle (1948) and Russell (1942) pointed out that floating mats of emergent plants may become clogged with debris, depositing an organic ooze on lake bottoms. Russell felt that this was the main sedimentary force in terrestrialization. Dansereau and Segas-Vianna (1952) noted that the fine peats which resulted often had a high mineral content.

Penfound and Earle (1948) emphasized that in their studies in Louisiana, floating platforms of *Eichhornia crassipes* provided the initial impetus for terrestrialization. These platforms both trapped water-borne sediments and provided a substratum for colonization by emergent aquatics and facultative wetland plants, thus obviating the necessity for a mineral-soil matrix.

Penfound and Earle (1948) described a succession from submerged aquatics to floating mat to floating prairie, to vegetation dominated by one

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* This is the first of two articles on the Kawainui marsh. The study fulfilled part of the requirement for the M.S. degree in Botany at the University of Hawaii.

This work was partially supported by the Water Resources Research Center, University of Hawaii and by the Department of Parks and Recreation, City and County of Honolulu. Thanks are extended to T. Minnick for his assistance with field and laboratory work, also to S. V. Smith for his valuable suggestions and criticisms.

Water Resources Research Center Contribution No. 109

or more of the colonizers, to willow forest. Depending on which of the taxa become dominant in the floating mat stage, a more or less firm sod may be formed. They reported that species of *Panicum* formed a firm sod which was readily traversed. However, cattails (*Typha* sp.) were ineffective in forming a firm sod.

Dansereau and Segadas-Vianna (1952) examined the dynamics of bog formation in North America. They outlined three major phases: pioneer, consolidation, and forest. These phases correspond to mat formation, peat deposition, invasion by facultative wetland plants, and establishment of woody plants.

Tansley (1953) gave an overview of succession in shallow-water lake communities in Britain. He reported that the causal factor in bog formation is the accumulation of peat, with waters becoming more acidic. His observations agree with those of Russell (1942) that succession is accomplished by the soil level approaching that of the water level, i.e., from the bottom upwards. Tansley refers to communities analogous with Kawainui as reed-swamps. However, the situation which he described did not include floating vegetation, but rather plants rooted in soil.

Penfound and Earle (1948) listed the taxa found in the floating mats of Louisiana. Of these the following are also found in Kawainui Marsh on floating mats. An asterisk denotes that Penfound and Earle found the same genus but a different species.

Scientific Name	Common Name
**Jussiaea leptocarpa* Nutt	primrose willow
Sonchus oleraceus L.	sow thistle
Scirpus americanus (C.A. Meyer) Stendel	giant bulrush
**Panicum* sp.	grasses
**Cladium jamaicense* Crantz	sawgrass
Eichhornia crassipes (Mart.) Solms	water hyacinth
*various duckweeds	duckweeds

Penfound and Earle (1948) also listed two taxa which occur in Kawainui but in mats of the grass *Brachiaria mutica* (Forsk.) Stapf., which are flooded only part of the year. These are *Sagittaria sagittaefolia* L. and *Typha latifolia* L.

Environmental conditions similar to those in Kawainui can be found in the Florida Everglades. The climate of the Everglades is subtropical (warm, humid) with distinct wet and dry seasons. The topography is flat, with an average slope of 0.04 m per km; water motion is almost imperceptible; large areas are without standing water during the dry season; the area is underlain by calcareous marine deposits. These two areas share some plant types. These are the sawgrasses, taro patch fern, and islands of woody plants. Some of the same woody taxa are present, *Ficus* sp. (fig) and *Melaleuca leucadendra* (Stickm.) L. (paperbark).

Loveless (1959) discussed the origin of tree islands and came to no conclusions. However, he did concur with Davis (1943) that in some situations it is plausible that they could have developed on floating chunks of peat or floating masses of vegetation. Robertson (1953) reached further into the origin of the tree islands to suggest that the occurrence is related to solution features which allowed pocket lakes to persist. In these lakes a peat layer developed and underwent succession to climax types of woody vegetation. These theories are essentially in agreement with Penfound and Earle's (1948) observations in Louisiana.

Egler (1952), on the other hand, suggested that the islands in the Everglades might be remnants of an aboriginal forest which has been restricted by fire. Loveless (1959) pointed out that Egler's hypothesis was supported by very little evidence.

Kawainui Marsh has been subject to some burning. Loveless (1959), Hofstetter (1974), Steward (1974), Davis (1943), Gore (1976), and Egler (1952) discussed the role of fire in the Everglades. Davis (1943) considered some sawgrass communities to be fire climaxes because of repeated annual burnings. Loveless (1959) noted that on tree islands of the Everglades fire apparently caused a reversion to a subclimax association of plants. During extreme drought (Loveless 1959) fire removed the peat as well as the vegetation from some of the tree islands. These areas became open water or covered with floating aquatics, of which some had sparse stands of sawgrass. Such a thorough burning appears to represent a reversion to a very early successional stage.

Hofstetter (1974) and others have pointed out that human manipulations of water levels in the Everglades have essentially extended the dry season, making fire a more devastating event. He listed some of the effects of fire there. The two effects of concern to this study were seed germination and modification of community composition.

Dansereau and Segadas-Vianna (1952) and Rigg (1940) discussed the chemical and physiological characteristics upon which wetlands may be classified into swamps, bogs, or marshes. On the basis of their classification, the area of Kawainui Marsh must be divided into two types: (1) a bulrush marsh with floating mats of live vegetation and peat deposition and (2) a bog meadow of California grass, flooded only during the rainy season and resting on mineral soil rather than peat. Both types are stream fed.

Plants

There is only one published source for information on the composition of the vegetation in Kawainui Marsh, a brief section by Elliott and Hall (1977) in a survey of Hawaiian Wetlands. Berger (1976) made a cursory examination of the plants growing in the peripheral areas. Some historical sources contain information about plants in the area. An 1851 map by Artemis Bishop (Fig. 1) shows 'aka 'akai (bulrush) growing adjacent to

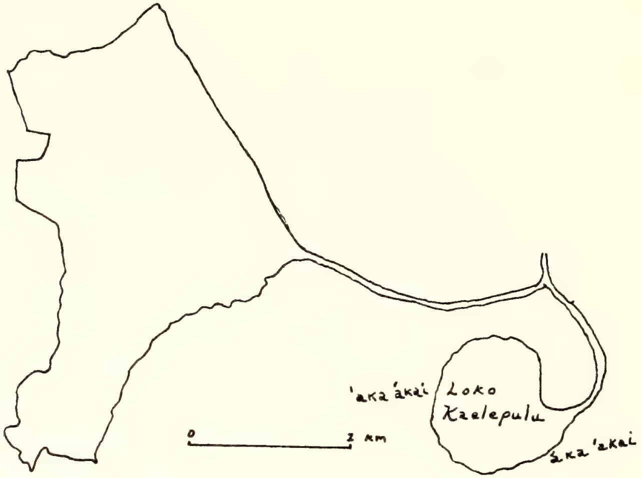


Figure 1. Drawn from a map by A. Bishop. 1851. State of Hawaii Land Survey. Honolulu. Scale is 1:25,000.

nearby Kaelepulu Pond, which was still denoted as a loko, that is a fishpond with an open connection to the sea.

Summers (1964) reported that algal mats were regularly cleared from the pond in Kawainui in pre-European times. She compared these mats with the growth found today on the bottoms of shallow fishponds in the Philippines.

One can only surmise that the sawgrass was present, as it is thought to be native to Hawai'i.

The taro patch fern is pan-tropical and a weed in taro patches. Since taro was grown in the area (McAllister 1933, Summers 1964) one may assume that it was present very early. Degener and Degener (1957) consider it to be a native plant. For some of the exotic plants in the marsh, dates of introduction are known.

The following is a survey of information about the conspicuous plants found in the marsh today. This survey is not meant to be inclusive but only to touch on points as they relate to the present discussion.

1. *Brachiaria mutica* (Forsk.) Stapf; family Gramineae
Para grass, panicum grass, California grass
Introduced 1902 (St. John 1973)

Whitney et al. (1939) described this grass as a "...spreading perennial, rooting at the lower joints, stems 6 to 8...sometimes 15 feet long, trailing and intertwining, forming dense masses..."

They reported it as widely planted for forage throughout the tropics and in Hawai'i one of the most important grasses in lowland pastures, growing luxuriantly in swampy areas. Henke (1929) described it as occurring on Kaneohe Ranch pastures, especially in periodically flooded areas, i.a., Kawainui Marsh.

Whitney et al. (1939) noted that the grass seemed to prefer wet areas. A paper by Vaźquez (1965) confirmed that irrigation significantly increased the yields of this grass, as did nitrogen application. He noted that the highest water consumption and yield occurred in spring and summer. Vaźquez suggested that the seasonal differences could be attributed to differences in temperature and day-length.

The maximum productivity recorded by Vaźquez (1965) was 112 mt./ha./yr. wet weight. Bown et al. (1966) reported a maximum production of 123 mt./ha./yr. for Hawai'i.

Bown et al. (1966) also reported that California grass establishes such thick mats of vegetation that "... in some areas ponds have been completely lost to view because of the floating layers of vegetation thick enough to support the weight of grazing cattle."

This grass has been controlled in Hawai'i by the introduction of geese to ponds covered with the plant (Ross 1976). Ross (1971) suggested that other waterfowl may be equally effective in controlling the growth of this grass.

California grass is the dominant plant in one of the two vegetation types in Kawainui Marsh.

2. *Cyclosorus interruptus* (Willd.) H. Ito; family Thelypteridaceae
Swamp cyclosorus, taro patch fern, marsh fern
Native, pan-tropical (Degener and Degener 1957, Fosberg and Sachet 1972)

Degener and Degener (1957) described this fern as occurring at lower elevations on all islands where habitat is suitable, in abandoned taro patches, ditches and around spring-fed ledges; occurring with sedges and grasses, spreading over large areas by means of rhizomes.

Loveless (1959) reported its occurrence on tree islands in the Everglades. Penfound and Earle (1948) reported a similar fern, *Dryopteris thelypteris* (L.) A. Gray (=*Thelypteris palustris*) as an early colonizer in floating mats in Louisiana.

The taro patch fern occurs in Kawainui Marsh sparsely throughout the ponding basin, on floating mats of emergent vegetation and in one small area (about 12 m in diameter) as an almost pure stand. In this area it forms a firm sod.

3. *Eichhornia crassipes* (Mart.) Solms; family Pontederiaceae
Water hyacinth
Introduced, early 1880's (St. John 1973)

Penfound and Earle (1948) wrote an extensive paper on the biology of water hyacinth. Among other characteristics they noted its buoyancy (sustaining a pressure of 43 kg./m.^{2}), its intolerance to slightly brackish water and its occurrence in slightly acid waters (pH 6.2-6.8).

They concluded that the seeds could not germinate under water, but that they needed a damp substratum of some sort.

Penfound and Earle (1948) noted that water hyacinth in Louisiana formed floating mats which were colonized by other plant species. This phenomenon has not been observed in Kawainui Marsh.

Except for one small pond which is periodically covered by hyacinth, the plant occurs rarely in the ponding basin of Kawainui Marsh. The measured pH of the water in this part of the marsh is 6.2. The salinity is 2^o/oo, well within the limits which this plant tolerates.

4. *Scirpus californicus* (C. A. Meyer) Stendel; family Cyperaceae
Great bulrush, 'aka 'akai, neki
Native (?) (St. John 1973, Koyama and Stone 1960)

If this plant was introduced, it may have been by the early portion of the 19th century. An 1851 map (Fig. 1) indicates 'aka 'akai at nearby and connecting Kaelepulu Pond. The plant indicated could also have been *Scirpus validus*, a very similar bulrush thought to be native to Hawai'i (St. John 1973). However, Fosberg (personal communication) considers the Hawaiian *S. validus* to be the same plant as the Hawaiian *S. californicus*.

A. Berger (personal communication) reported that migratory wildfowl feed on the seeds of *Scirpus californicus*, making its transport by birds a distinct possibility. This being the case, there seems to be no need to call upon human introduction as a dispersal mechanism to Hawai'i.

I am inclined to accept Fosberg's synonymy of these two Hawaiian species of *Scirpus*, thereby concluding that bulrush was present in the marsh, as a native plant, from pre-Polynesian times.

Penfound and Earle (1948) reported both *Scirpus validus* and *S. californicus* on the floating mats in Louisiana. Hotchkiss (1970) gave its mainland range as California to South Carolina, Texas and Florida.

Scirpus californicus is the dominant plant in the ponding basin of Kawainui Marsh. It forms thick floating mats which are colonized by other plant species.

5. *Typha latifolia* L.; family Typhaceae
Cattail
Introduced (St. John 1973)

Tansley (1953) mentioned species of *Typha* in his study of British lakes. He noted that they tended to occur where siltation is fairly constant and the water is shallow. Harris and Marshall (1963) found in their study of Agassiz National Refuge in Minnesota that reflooding to about 0.3 m killed the *Typha*.

This plant occurs in the upper, periodically flooded portion of Kawainui Marsh as discrete, almost pure stands 5-10 m across. These stands, rooted in soil, do not form mats or sod.

6. *Cladium leptostachyum* Nees & Meyen; family Cyperaceae
Sawgrass, 'uki
Native (St. John 1973)

This plant was formerly considered a subspecies of *Cladium jamaicense* Crantz; it is *C. jamaicense* which is reported in the studies examined from other areas.

Penfound and Earle (1948) reported *Cladium jamaicense* as an early colonizer of floating mats in Louisiana. They further noted that it did not form a firm sod. Loveless (1959) reported sawgrass marshes as one of the major vegetation types in the Everglades. He noted pure stands of sawgrass formed transition zones between the tree islands and open marsh communities.

Steward and Ornes (1975) studied the nutritional needs of sawgrass in the Everglades and found that it had very low nutritional requirements, as well as a low capacity to assimilate added nutrients.

Cladium leptostachyum is found in the ponding basin of Kawainui Marsh. It forms thin, floating mats. It is occasionally interspersed with bulrush, but occurs mainly as almost pure stands.

Davis (1943) and others have noted that sawgrass growth seems to be enhanced by repeated burnings of marsh areas. Past fires may have contributed to the abundance of sawgrass in Kawainui Marsh.

7. *Melaleuca leucadendra* (Stickm.) L.; family Myrtaceae
Paperbark, cajeput tree
Introduced, 1929 (St. John 1973)

Gore (1976) and O'Brien (personal communication) reported that biologists in the Everglades considered paperbark to be a fire invader, replacing cypress and pine in burned areas. They reported that multitudinous seedlings were found in areas which had just been burned.

Thirty paperbark trees tall enough to be visible over surrounding plants occur in Kawainui Marsh. They are rooted in floating mats of bulrush and sawgrass. Seedlings were found after a fire in August of 1975. However, none are known to have survived.

Kawainui Marsh

Geology

Takasaki et al. (1969) summarized the geology of the area. The marsh (Fig. 2) lies near the center of the ancient Ko'olau Caldera in an area known as Maunawili Valley. Stearns and Vaksvik (1935) described throat brecceas outcropping between Kāne'ohe and the marsh. They concluded that these were the site of the main vent of the Ko'olau Volcano. Adams and Furumoto (1965) showed with seismic profiles that the volcanic plug lies at three to four-km depths in this area.

Eustatic changes in sea level have alternately left the area submerged and emergent. During an emergent period stream erosion destroyed the caldera and carved the fluted valleys (Stearns 1966) now evident in the Nu'uanu Pali. A higher stand of sea level resulted in the deposition of both consolidated and unconsolidated marine sediments. Re-emergence of the area to nearly its present level allowed for the formation of the barrier beach dunes (Stearns 1935) separating the marsh from Kailua Bay. The Coconut Grove area of Kailua now occupies a portion of this barrier.

Cores taken in the marsh (Stearns and Vaksvik 1938) revealed silty clayey marls interbedded with coal detritus and alluvium to depths of 30 m. This alluvium (Takasaki et al. 1969) is reworked older alluvium from upper valleys in the area. The older, upper valley alluvium is the erosional product of a former high stand of sea level.

Borings and probes of the marsh were reported by Dames and Moore, Inc. (1961). These showed a dark grey marine clay and marine sand with shells down to about 38 m without finding firm rock. The marine sediments were overlain by an organic slurry, which was overlain by peat. The peat, in turn, graded into the live roots of the present vegetation. The Dames and Moore, Inc. (1961) report contained core and probed data from three previous surveys as well as their own work.

Towill Corp. (1964) reported the marsh to be covered by a thick blanket of peat and vegetation, relying on the Dames and Moore, Inc. (1961) report for coring information, as did Swain and Huxel (1971).

Volcanic activity of the Ko'olau and Kailua series (Stearns 1946) formed the main structural features of Maunawili Valley. The area is heavily intruded by dike complexes (Stearns and Vaksvik 1935) which affect the patterns of ground water flow. The Kailua series are dense, massive and poorly permeable; they are characteristic of restricted caldera-formed lavas (Takasaki et al. 1969). Their permeability is further restricted by subsequent hydrothermal mineralization.

The Ko'olau series consists of lavas deposited outside the caldera and not subject to hydrothermal alteration. This series forms the aquifer for Maunawili Valley. Permeability is, however, variable as it is affected by the presence of dikes, the differing permeabilities of 'a'ā and pāhoehoe flows, and secondary mineralization.

Maunawili Valley is bounded by rocks of both series. Cliffs formed from the more permeable Ko'olau series lie on the southeast side of the basin. The northeast-striking ridges separate the basin from Kāne'ohe to the north and from Waimānalo to the south (Takasaki et al. 1969).

Most of the engineering and consulting papers available on the area contain some information on its geology, mainly taken from Stearns' various publications.

Soils

The marsh receives sediment from two soil associations. The Ka'ena-Wailua association is described (U.S.D.A. 1972) as "... deep mainly nearly level and gently sloping, poorly drained soils that have a fine-textured subsoil; on fans, terraces, and uplands.

The main body of the marsh is reported in the U.S.D.A. publication (1972) merely as marsh soils with a smaller portion (roughly one-third) of the area at the upper end divided equally into Pearl Harbor clay and Hanalei silty clay, both of which belong to the great soil group typic tropaquepts (grey hydromorphic). These soils are montmorillonitic, non-acid clays. Dames and Moore, Inc. (1961) describe the soils series of the remainder of the marsh as peat, underlain by organic silt, underlain by marine sands.

Climate

Mean annual rainfall from 1959 through 1975 was about 1,050 mm (Dept. of Land and Water Development, Hawai'i). This mean is based on daily records from the National Weather Service gauge #2683 at the Kailua Fire Station, less than 0.6 km from the marsh. The Honolulu Board of Water Supply (1975) reported a mean annual temperature of 24°C with a maximum of 27°C and a minimum of 20°C. They gave the relative humidity as 70 to 80%. Mean insolation is about 3,800 kcal/m^2/day (Hawaii Institute of Marine Biology, Mōkapu Penninsula data).

Water

Maunawili Valley and Kahanaiki Streams enter the marsh at its upper end. The net flow is about 25,600 m^3/day (Takasaki et al. 1969). A small, intermittent stream enters the marsh from below the rock quarry on the west. Its flow rate is unknown. Sewage effluents from two treatment plants enter the marsh directly. The plants went into operation in 1961 and 1957 and empty a combined volume of about 1,200 m^3/day. Effluents from two other sewage treatment plants enter via Maunawili Stream. These were constructed in 1965 and discharge about 570 m^3/day. The total effluent from all four plants is about 1,700 m^3/day, into an area of 280 ha. All effluents are secondarily-treated. Data on sewage effluents are from the Department of Public Works, City and County of Honolulu.

Terrigenous storm runoff enters from housing subdivisions along Kailua Road and from a sanitary landfill and a quarry east of the marsh. To a first-order approximation, water entering the marsh from all sources is estimated as 36,000 m^3/day.

Kawainui Stream, the natural outlet for the marsh, is now cutoff from the marsh by an earthen levee at Coconut Grove in Kailua. A report (Swain and Huxel 1971) prepared by the U.S.G.S. makes it clear that there is no seepage through the levee at Coconut Grove from the marsh. Hence, Kawainui Stream no longer receives water from the marsh or contributes to it.

Kawainui Canal (Fig. 2), which is tidally controlled, is effectively blocked from intruding the marsh by a weir of vegetation. Swain and Huxel (1971) showed that the water in the marsh normally remains higher than high tide levels in Kawainui Stream, maintaining a head against saltwater intrusion. This being the case, it is unlikely that Kawainui Canal exercises any tidal control over water height in the marsh or that salinity intrusion is very great. In addition, continuous chart recordings of U.S. G.S. surface water gauge #1626-48 near the head of Kawainui Canal show no perceptible tidal effect for 1970 through 1975. That gauge is now gone, but a staff gauge remains. Periodic readings have shown the range to be the same.

Surface water in the marsh is fresh. Bienfang (1974) reported a salinity of 2°/₀₀. Bienfang (1974) reported observations of the temperature of Maunawili and Kahanaiki Streams as well as Kawainui Canal as 24° C. Measurements made in this study confirm Bienfang's salinity and temperature measurements. The pH of surface water near the levee is 6.2.

About 1,900 m^3/day of water which would be tributary to the marsh is diverted by the Honolulu Board of Water Supply. The tunnels are designated Waimanalo I, II, III, and IV (C. Lao, personal communication). The Waimanalo Irrigation System diverts about 7,500 m^3/day from all Maunawili Valley sources, including Maunawili Ditch (Takasaki et al. 1969, Hawaiian Water Authority).

Some water must leave via Kawainui Canal, via evapotranspiration, as ground water, and for domestic use. Domestic use can only be trivial, being possibly that of one or two householders living on the northwestern fringes of the marsh. Groundwater losses are probably small. Community Planning, Inc. (1977) reported that the organic silt which underlies the marsh is nearly impermeable. Thus, groundwater seepage is probably negligible.

Takasaki et al. (1969) recommended a formula for estimating evapotranspiration for windward O'ahu from rainfall data. Evapotranspiration

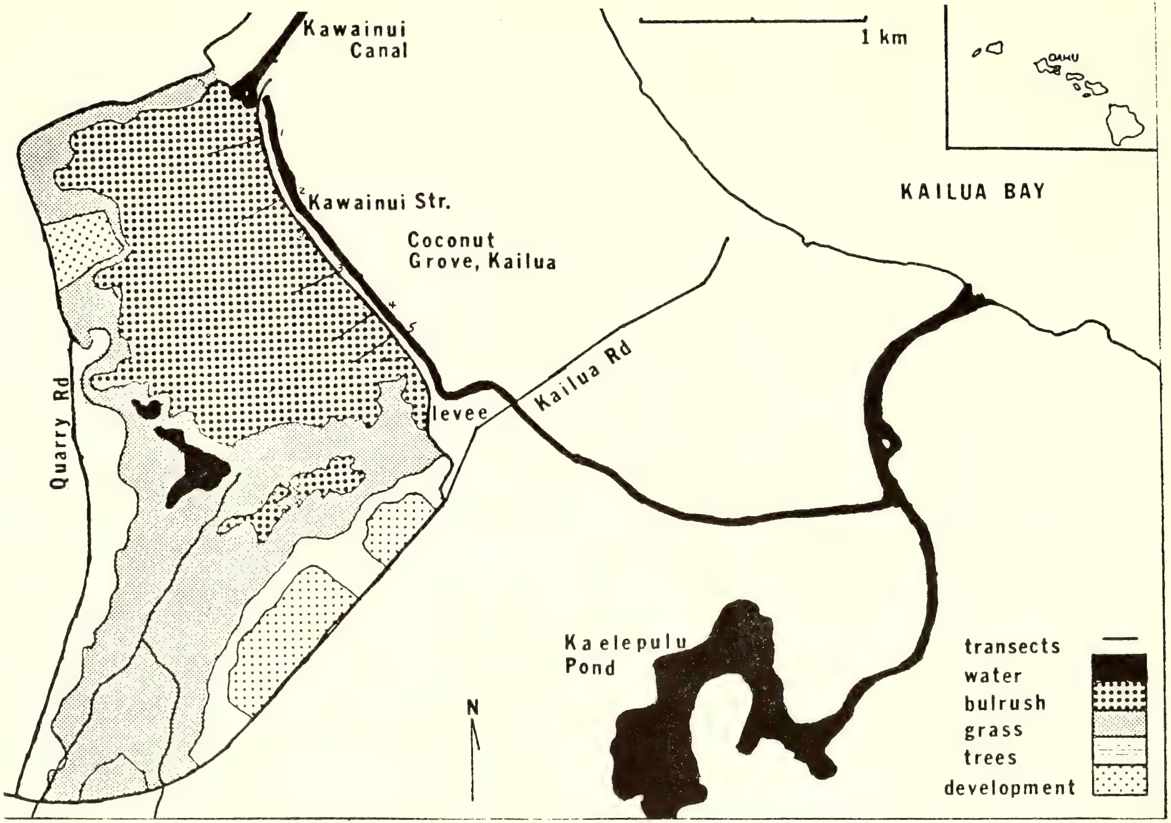

Kawainui Canal
1 km
KAILUA BAY
OAHU
1
2
Kawainui Str.
Coconut Grove, Kailua
3
4
5
Kailua Rd
levee
Quarry Rd
Kaelepulu Pond
N
transects
water
bulrush
grass
trees
development

Figure 2. Vegetation map of Kawainui Marsh. Drawn from 1974 aerial photograph, NASA. Transects are located by the numbered lines shown near the levee. These transects are not shown to scale, but only indicate position. The scale of the map is 1:24,000.

as estimated this way for the entire marsh would be about 12,000 m^3/day, or 33% of the total water budget.

H. Wong, of Kaneohe Ranch (personal communication) reported that pumping water from the marsh into Kawainui Canal at a rate of 37,700 m^3/day kept water levels in the marsh from 1955 through 1965 at a constant -1.5 m msl. Calculations made from independent data [Takasaki et al. 1969, estimates of rainfall (Blumenstock 1961) and runoff] gave a total input of about 36,000 m^3/day. This figure closely agrees with Mr. Wong's and probably accounts for almost all surface water in the marsh. Shaw (1927) reported that a maximum of 37,700 m^3/day and a mean of 30,160 m^3/day were available from all of Maunawili Valley for sugarcane irrigation.

History of Land Use and Management

The earliest recorded use (McAllister 1933) of the marsh is as a fishpond in which milkfish (*Chanos chanos*) and mullet (*Mugil cephalus*) were grown. This pond, as well as Ka'elepulu, were (Summers 1964) under the jurisdiction of the konohikis (land agents) of the ali'i or ruling class. McAllister (1933) also reported that the area was a favorite residence of the ali'i.

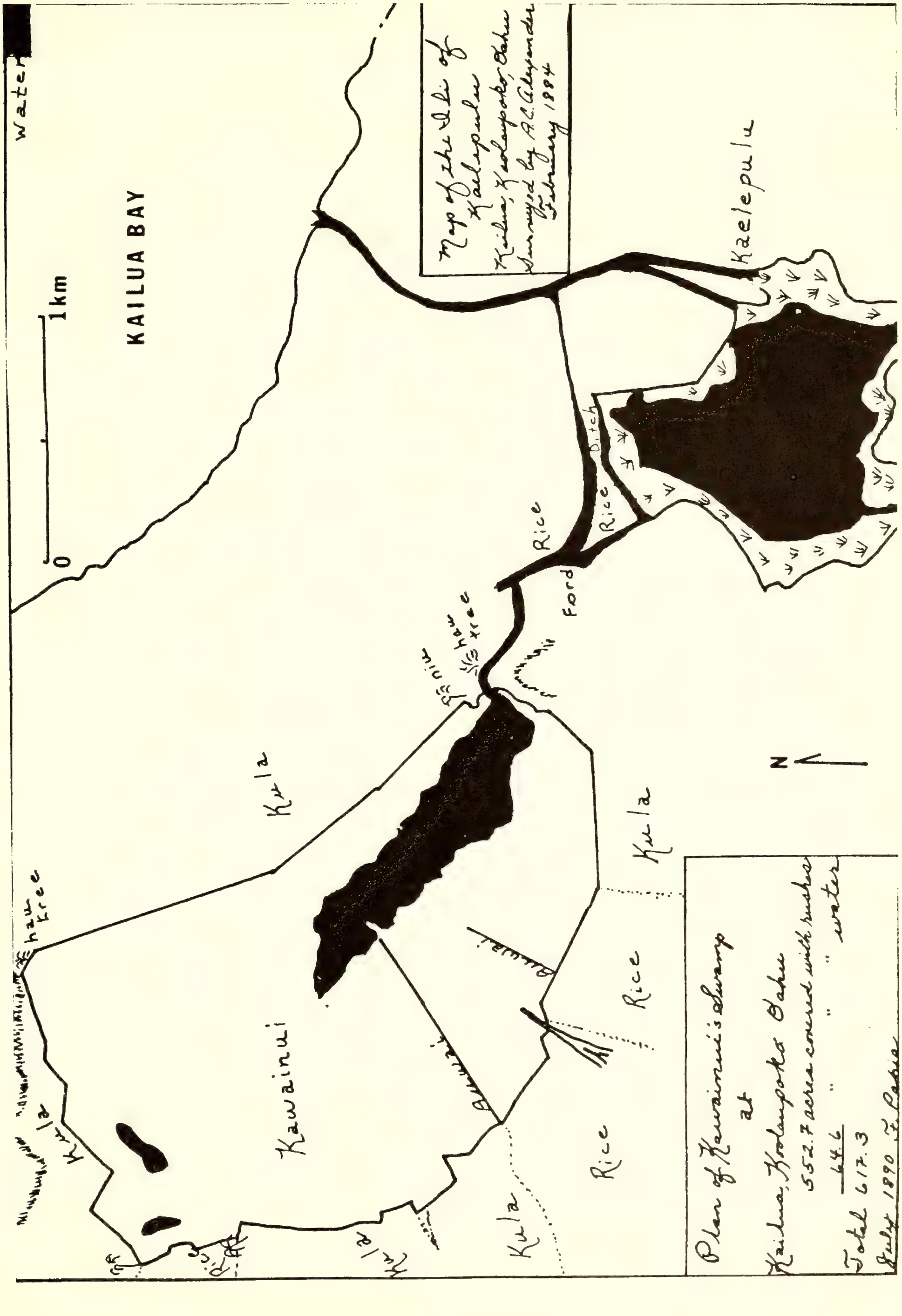
Summers (1964) stated that the fishpond was about 180 ha in extent. A 1961 soils report by Dames and Moore, Inc. estimated the extent of peat soils to be about 180 ha. As the peat probably formed in the lake body after its abandonment as a fishpond, Summers' estimate for the size of the lake was probably correct.

There were taro patches on the upper slopes of the marsh and between Kawainui and Ka'elepulu Ponds. The water from Kawainui was diverted into the taro patches and ran into Ka'elepulu Pond (McAllister 1933). When the taro lands were being dried, the water ran through a ditch directly into Ka'elepulu Pond (McAllister 1933). Mākāhā (gates) were placed in the streams to prevent the fish from escaping (Mahoe 1953).

With the abandonment of fish culture, taro and dryland farming continued. Rice became an important crop after 1860 (Coulter and Chun 1937, Pratt 1965). An 1884 map (Fig. 3) shows land devoted to rice. Davaney et al. (1976) reported the earliest rice culture on windward O'ahu in the 1860's. Coulter and Chun (1937) and Pratt (1965) confirm that rice growing was prevalent in Kailua by 1876. Former taro patches as well as previously unused land were converted to rice.

Figure 3 (opposite). Map of the Kawainui Marsh area as it would have appeared between the years 1884-1890. This is a composite of two maps, the left-hand portion being one drawn in 1890, and the right-hand portion in 1884. The original maps were reproduced as facsimiles and then reduced to a common scale of 1:24,000 and joined to produce this composite map of the area. The original map legends were superimposed on the composite.

The 1890 map was furnished courtesy of the B. P. Bishop Museum, Honolulu. The 1884 map is on file at the State of Hawaii Land Survey Office, Honolulu.


water
KAILUA BAY
0
1km
N
Map of the Ili of
Kaelepulu
Kailua, Koolaupoko, Oahu
Surveyed by A.C. Alexander
February 1884
Kaelepulu
Ditch
Rice
Rice
Ford
hau tree
niu
Kula
Kula
hau tree
Kawainui
Rice
Rice
Kula
Kula
Kula
Plan of Kawainui's Swamp
at
Kailua, Koolaupoko Oahu
552.7 acres covered with rushes
64.6 " " water
Total 617.3
July 1890 J. Pahia

The rice growers constructed weirs on Kawainui and Ka'elepulu Streams to prevent the incursion of saltwater and used the marsh water to irrigate their rice fields (McAllister 1973). Recently (1975) Honolulu Magazine published a photograph of Mt. Olomana taken in 1926. This photograph showed rice fields in Kawainui.

Production of rice steadily declined after about 1900 (Coulter and Chun 1937). By 1934 only 1,000 kg were produced in the entire Territory of Hawai'i.

With the establishment of Waimanalo Sugar Plantation in 1878 (Anonymous 1882) water from Maunawili Valley was diverted to irrigate cane fields. An 1899 map (Fig. 4) shows a diversion ditch and pump in place in Kawainui Marsh. Harloe (1948) reported that Kaneohe Ranch (founded 1890) had begun selling water from the marsh to Waimanalo Sugar in 1924. Shaw (1927) stated that the plantation was using water both from Kawainui and a Maunawili Stream diversion. He also reported that the plantation took 15,000 m^3/day from Kawainui. Gilmore (1931) reported that the irrigation ditch in Kawainui was drawing on a 200-ha lagoon. H. Wong (personal communication) said that the marsh was dammed at the present intersection of Kawainui Stream and Kailua Road in the winters to prevent water losses during the time that Waimanalo Plantation used the water. He estimated that this use ceased in 1950, which agrees with the proposed termination date reported by Harloe (1948).

By the time that Kailua Ditch from Kawainui was no longer in use, a diversion ditch was constructed on Maunawili Stream (Shaw 1927) so that fresh water was diverted above the marsh. This diversion still operates.

Kaneohe Ranch was begun in 1890. A report (1929) by Henke strongly suggests that Kawainui was used for grazing from that time. He described the property as extending inward from the sea at Kailua to the Pali. Henke noted in his report on range grasses that *Brachiaria mutica* "... does well in low places which are partially submerged with water during part of the year."

In 1952 Kawainui Canal was dug. A weir was installed as proposed by Harloe (1948) to keep out saltwater. This also had the effect of cutting-off Kawainui Stream from the marsh, while diverting marsh water through the new canal to Kailua Bay.

From 1955 to 1965 Kaneohe Ranch maintained a pump at the head of the canal. This was done specifically to increase the grazing lands for Kaneohe Ranch cattle. A weir was maintained in order to prevent saltwater intrusion.

In 1966, Kawainui Canal was enlarged and a 3-m high levee was constructed between the marsh and Coconut Grove in Kailua. This marked the end of direct management of marsh waters.

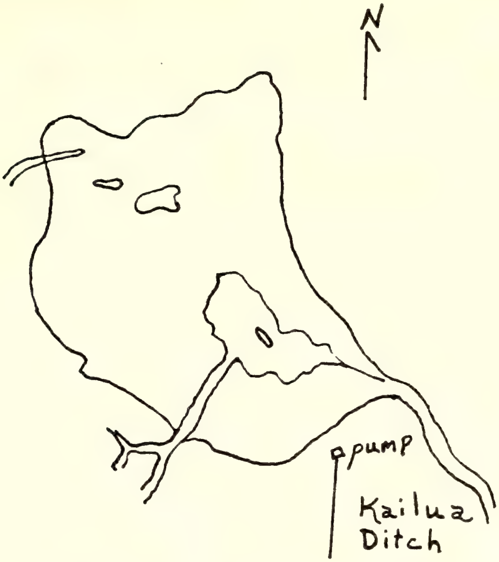


Figure 4. Drawn from a map by W. A. Wall. 1899. State of Hawaii Land Survey. Honolulu. Scale is 1:24,000.

S. Chinn (personal communication) estimated that the long-term mean water level for Kawainui Marsh at U.S.G.S. surface water gauge #1626-48 is 1 m msl with a range of 0.6 to 1.2 m.

Present uses of the marsh include grazing for cattle and horses in the upper marsh. A car-wrecking yard is present on the Kāne'ohe side. There is also a small park built on land-fill beside the Quarry Road. The marsh receives the runoff from a housing development on Kailua Road, from a landfill and quarry. A few persons reside as squatters near Quarry Road. Many more (P. Siefermann, personal communication) have done so in the past. Along Quarry Road there is also a horse stable and warehouse for a swimming pool construction company.

Fauna

Only fragmentary observations of the fauna are available. Berger (1976) reported the following birds in Kawainui:

Endemic Species

Common Name	Scientific Name
1. Koloa or Hawaiian Duck	*Anas wyvilliana*
2. Hawaiian Gallinule	*Gallinula chloropus sandvicensis*
3. Hawaiian coot	*Fulica americana alai*
4. Hawaiian black-necked stilt	*Himantopus h. knudseni*

Other Indigenous Birds

	Common Name	Scientific Name
1.	Black-crowned night heron	*Nycticorax h. hoactli*
2.	Pacific golden plover	*Pluvialis dominica fulva*
3.	Wandering tattler	*Heteroscelus incanus*
4.	Pintail	*Anas acuta*
5.	Shoveler	*Anas clypeata*

Introduced Birds

1.	Cattle egret	*Bulbulcus ibis*
2.	Feral pigeon or rock dove	*Columba livia*
3.	Spotted or Chinese dove	*Steptopelia chinensis*
4.	Barred dove	*Geopelia striata*
5.	Melodious laughing-thrush	*Garrulax striata*
6.	Red-vented bulbul	*Pycnonotus cafer*
7.	Shama thrush	*Copsychus malbaricus*
8.	Japanese bush warbler	*Cettia diphone cantans*
9.	Japanese white-eye	*Zosterops j. japonica*
10.	Common Indian mynah	*Acridotheres t. tristis*
11.	House finch	*Carpodacus mexicanus frontalis*
12.	Ricebird or spotted munia	*Lonchura punctulata*
13.	House sparrow	*Passer domesticus*
14.	Cardinal	*Cardinalis cardinalis*
15.	Red-crested cardinal	*Paroaria coronata*

Berger cautioned that his study was conducted in the summer only and that other species of birds are likely to be present in other seasons of the year.

Ford (1975) prepared a report, unpublished, on a preliminary survey of the marsh. In the waters of the central and upper marsh he found fish of the family Poecilidae [top-water minnows, *Tilapia mossambica*, one carp (*Cyprinus carpio*), and a rice eel (*Monopterus* sp.)].

Along the middle and lower course of Maunawili and Kahanaiki Streams Ford found the gastropod *Melania* sp., caddisfly larvae (*Cheumatopsyche analis*), two species of chiromid larvae, some small leeches, a crayfish (*Procumbus clarkii*), amphipods, isopods, a polychaete (*Namalycastis* sp.), toad and frog tadpoles, poecilid fish, Chinese catfish (*Calrias fuscus*), a smallmouth bass, and *Tilapia mossambica*.

Other animals observed in the marsh include cattle and horses grazing in the upper portions of the area. Cattle egrets roost in the trees surrounding the marsh. They feed in the landfill above the area. Mongooses are quite common, building their burrows through dense mats of California grass.

Direct human uses include the use of the levee for jogging and riding trail bikes. Children in the area report fishing in the lakes in the upper portion of the marsh. Fishermen were seen at the head of Kawainui Canal on several occasions.

Gaily festooned trees and other decorations bear mute testimony to counter-culture activities in the area, probably at night. M. Knott (personal communication) reports that people commonly search his pastures for a mushroom thought to be hallucinogenic. Thus, active recreational use of the marsh is slight, but diverse in nature.

Vegetation

The marsh vegetation is comprised of two major communities: (1) a grass community composed of an almost pure stand of *Brachiaria mutica* on the upper, mountainward side of the marsh and (2) an area of *Scirpus californicus* mixed with sawgrass, taro patch fern, and minor amounts of other species. This community is aquatic and occupies the area on the Kailua side of the marsh.

The upper slopes of the marsh (from about the 3 m topographic contour) are wooded, mainly with *Leucaena leucocephala*, *Psidium guajava*, *Ficus microcarpa*, and *Samanea saman*.

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THE KALAPANA EXTENSION OF HAWAII VOLCANOES NATIONAL PARK: ITS VARIETY, VEGETATION, AND VALUE

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This paper provides a glimpse of the natural history of the eastern third of Hawaii Volcanoes National Park called the Kalapana Extension. This area of approximately 75 square miles was added to Hawaii Volcanoes National Park following a 1938 Congressional authorization. It runs from the rocky coast up to 2500 to 3000 feet elevation, and almost all is east of the boundary between the Puna and Ka'ū districts, near the western edges of the recent Maunaulu lava flows.

More interesting than the political limits is the main geographical one--that is, nearly the whole region lies along and down slope of the volcanically very active East Rift of Kīlauea. There are two main geological features which are of particular importance to the distribution of vegetation in the region. These are the many lava flows and the Hilina Fault System.

The lava flows exhibit several textural surfaces of 'a'ā and pāhoehoe lavas. In the upper slopes near the rift, most of the surface consists of geologically recent pāhoehoe flows with fairly vesicular rock. Some flows have smooth, shelly surfaces and others are very slabby and rough. A few of these pāhoehoe flows turn into 'a'ā flows downslope, sometimes with a transition of very blocky pāhoehoe.

If an eruptive phase lasts long enough, as in the Maunaulu series, then large portions of the original flows may be covered by denser, degassed pāhoehoe carried by extensive tube systems. Generally, these tube-fed flows extend much farther downslope, and comprise most of the surface area at lower elevations in the Kalapana Extension.

Observations of vegetation growing on these different surfaces of a flow or a series of flows indicate that forest development occurs much more rapidly on the 'a'ā and rough textured pāhoehoe than on the denser, tube-fed pāhoehoe farther from the vent.

An important feature of lava flows is the common occurrence of the kīpuka, an island of older substrate and vegetation surrounded by younger lava flows. In such a volcanically active area as the East Rift of Kīlauea, much of the surface is a patchwork of different aged kīpukas. Walking through the area will provide one with examples of steps in the development of forests and the succession of species within them.

The other important, geological feature of the area is the Hilina Fault System, which has produced several fault scarps. The numerous earth movements along these scarps have extensively fractured the lava to give it a structure similar to that of 'a'ā. The scarp areas may also have increased moisture due to seepage. Where not covered over by more recent lavas, the scarp areas tend to act as kīpukas, very often harboring the best developed forest of the immediate area.

In addition to the lava substrates, there are two cinder cones in the Kalapana Extension. These have on their slopes ash deposits, which give rise to a different kind of soil and have on at least one of them a few plants not seen elsewhere in the Extension.

Superimposed on the geological setting of the region are two rainfall gradients. In addition to the usual orographic increase in precipitation with elevation, there is a northeast to southwest decrease representing a gradual shift from windward to leeward exposure. The range in precipitation over the Kalapana Extension allows for eventual development of wet, mesic and dry forest zones, and examples of each can be found here.

All or nearly all of the lava and ash surfaces appear to be young enough that their age is reflected by the degree of development of the vegetation upon them. The influence of the rainfall and elevation gradients on the different kinds and ages of substrates has resulted in a mosaic of various vegetation types. Disturbances from fires, agriculture and introduced plants and animals have added to the region's heterogeneity.

Due to the recurrence of lava flows with the newer ones at least partially covering the older ones, the exposures of the older ones usually have been reduced to fragments, and the oldest tend to be the least common. It is in these older kīpukas and flow segments that the most diverse plant communities are located. As most of the many rare and uncommon plants in this section of the Park are found only in the more mature communities, their distributions are naturally patchy.

As mentioned, dry to wet moisture regimes allow for the eventual development of corresponding forest types. The most prevalent are the rain forest communities distributed in the wetter and higher parts of the region. Of these, the most diverse and pristine examples in the Park grow in a recent kīpuka on and just downslope of an unnamed cinder cone along the East Rift. The dry forest communities are more scattered over the lower to middle reaches of the Kalapana Extension. Some of the best lowland dry forest left in the Islands occurs on an old 'a'ā flow in the Kamoamoa ahupua'a here.

There are several areas of mesic forest that have developed between representatives of the previous two types, mostly on the fault scarps above the Kalapana Trail. Here grow some of the largest trees in the Park--*Metrosideros* well over a meter in diameter and 30 m tall and, on another substrate, *Tetraplasandra hawaiensis* up to 1.5 m in diameter. There is also a sizable part of the Kalapana Extension that is very open forest, scrub, grassland and barren lava. Those areas probably reflect past disturbances, early plant colonization, and limiting rainfall as well as very recent lava flows.

The quality of these forest types varies greatly with the degree of successional maturity and especially with the amounts of disturbance to which they have been and are being exposed. In some of the lower and middle elevations there has traditionally been some agriculture, and later, grazing practiced. In an area of such volcanic activity, periodic fires have fringed the lava flows. Within the last fifteen years or so, two introduced species of *Andropogon* (broomsedge) have invaded a large part of the park where the forest has been open enough. Since then, the size and severity of wildfires in this region have greatly increased.

These grasses are just two of the many species of introduced plants and animals which threaten the integrity of the forests of the Kalapana Extension. Other species include *Myrica faya*, two species of *Psidium*, *Stachytarpheta jamaicensis*, *Leucaena leucocephala*, *Lantana camara*, and *Eugenia jambos*. Establishment of most of these and other problem exotics in the Extension is enhanced by disruptions of the native vegetation from fires and sustained feeding activities of feral mammals. In some of these disturbed areas one can see dense patches of one or more of the previously mentioned plants, and the prospect is for much more of the same.

While feral goats have recently been rendered scarce in the Park, their effects can still be seen. In many of the drier scrub and forest areas of the Extension, their selective browsing has all but eliminated the native understory.

Much more of a problem are the hordes of feral pigs, especially in the rain forests, where their ravages are the most evident. As with goats, their selective feeding has severely depleted certain species. More important is habitat destruction. The pigs disrupt and in large areas have eliminated the *Cibotium* understory by killing the tree ferns in the process of eating the quantities of starch inside them. Where the lava is not too rugged, they have stripped the ground of its naturally dense cover of vegetation by their digging activities, exposing it to invasion by weedy exotics. The spread of exotics in the genera of *Psidium*, *Rubus*, and *Passiflora*, at least, is no doubt accelerated by seed dispersal through their feces.

The consequences of the tremendous numbers of pigs in the Park's forests is a clearing, plowing, and sowing not unlike a primitive agriculture, complete with considerable soil erosion. Even the epiphyte habitats have been altered by this exposure and resultant desiccation. The uncommon epiphytes are lost, and only the hardiest survive.

It is no coincidence that many of the rare and uncommon plants in the Kalapana Extension, as elsewhere in the Park, are restricted to places where the local geography allows for protection from feral animals. Pit craters, large earth cracks, a few of the recently isolated kīpukas, rough 'a'ā and slabby pāhoehoe substrates, and in a few instances proximity to human activities have acted as partial or complete protection from goats or pigs. Comparison of these fragments of protected areas with their disturbed counterparts provides good examples of these alien animals' enormous influence.

In spite of the considerable problems present in managing its biological resources, the Kalapana Extension has tremendous value to its natural inhabitants and to the appreciative people who pass through it. The region is dominated by its active geology, and its interaction with life forces. There is no better place in Hawai'i to observe the sequences of forest development on both young and old lava flows. As sanctuaries for many native species it contains the best dry and rain forest habitats in the Park. One also has the opportunity to observe relatively pristine rain forests in some of the few pig-free areas.

REPORT OF THE NATIVE PLANT COMMITTEE

The Hawaiian Botanical Society Committee on Native Plants is gathering objective data concerning Hawaii's rare and endangered vascular plants. Committee members include Drs. Derral Herbst, Charles Lamoureux, Gerald Carr, Mr. John Obata and Dr. Daniel Palmer.

At present, there is only one Hawaiian plant officially listed as endangered, *Vicia menziesii* Spreng. This is partially because there are very few objective data regarding the current status of these plants. The Fosberg-Herbst list (F. R. Fosberg and D. Herbst. 1975. Rare and Endangered Species of Hawaiian Vascular Plants. Allertonia 1(1): 1-72) of rare and endangered species of Hawaiian vascular plants contains 893 plants, and before any of these can be accorded protection by law, documentation must be available. Any information we gather will facilitate the legal protection of these unique Hawaiian plants.

We currently have part time employees collecting data from herbarium sheets at the Bishop Museum and at the University of Hawaii. We also have a small cadre of volunteers gathering field data concerning the plants on the Fosberg-Herbst list of proposed rare and endangered species of Hawaiian vascular plants.

We need workers to gather field data. At present we have very limited funds and all work would necessarily be voluntary.

The field data should include the name of the plant, the island on which it is found, a precise description of its location (including reference to USGS quadrant maps if possible), its elevation, exposure, description of habitat including soil, numbers of seedlings, saplings, mature and senescent plants, data regarding flowering and fruiting, threats, colony area, and other pertinent information. We have field data sheets with instructions that will be given to volunteers.

Our committee is attempting to contact all the individuals who can help us accumulate this information. Some of you will have broad knowledge of certain plants; others will have knowledge regarding rare and endangered plants of a specific geographical area.

If you are willing to help the Botanical Society collect this information, please inform me. Those who contact me will receive field data sheets and detailed instructions.

Our list of people knowledgeable in the Hawaiian Flora is not complete. We would appreciate the names and addresses of any who you feel could be of help. We are particularly in need of volunteers from islands other than O'ahu.

A copy of our field data sheet with notes clarifying the items listed on the sheet is printed below.

TAXON: ______________________________
DATE: ____________ ISLAND: ____________ DIST: ____________
AHU: ____________________ LOCATION: ____________________
____
____
ELEV: ____________ SLOPE: __________° EXPOSURE: ____________
SUBSTRATE: ______________________________
LIGHT: Full Sun ____ Intermediate ________ Deep shade ____________
HABITAT DESCRIPTION: ______________________________
HABIT: ______________________________
SIZE: Avg. Height __________ Spread __________ Dia. __________
COLORS: ______________________________ ODORS: ____________
____________ PHENOLOGY, etc: ______________________________
CENSUS, # of: Seedlings ________ Saplings ________ Mature ________
Senescent ________ COLONY AREA: ______________________________
COLONY CONDITION: ______________________________
THREATS: ______________________________
COMMENTS AND VEGETATION NOTES: ______________________________
____
____
COLLECTOR ______________________________ # ____________

Substrate:

The type of soil which the plant is growing should be recorded. General lay terms as the following may be used: sand, clay, gravel, weathered or "rotten" lava, silt, humus, volcanic ash, 'a'ā lava, etc.

Habitat Description:

Briefly describe where the plant is growing. Is it a rain forest plant, a plant of coastal sand dunes, a floating aquatic, etc? Also, specify if it is an epiphyte (growing on but not parasitizing another plant); if parasitic, record the host plant.

Habit:

Characteristic shape, form or manner of growth of a plant, e.g., tree, vine, shrub, herb, scandant, dense crown, straight bole, etc. are terms used to describe the habit of a plant.

Size:

Specify if measurement is in meters or feet.

Color:

Record the color of any part of the plant, as leaves or flowers, whose color may change when the specimen is dried.

Phenology:

Record the stage of growth of the plant; i.e., is it in full flower, have immature fruit, ripe fruit, a recent flush of new leaves, etc.

Census:

An accurate count of the number of individuals in each category gives an indication of the health of the population.

Senescent:

Showing signs of old age.

Colony Area:

Indicate how widely distributed the plant is. For example, is the population scattered throughout the entire valley floor, is it restricted to a 10 acre plot on a talus slope?

Colony Condition:

Include general observations on the condition of the entire population. Is it healthy and regenerating, insect or disease ridden, browsed, etc?

Threats:

This is an important item. Record any observations that may explain why the species is endangered; for example, seeds eaten by rats, competition from aggressive weeds, limited numbers or range of plant, fire hazards, pig damage, signs of browsing, etc.

Comments and Vegetation Notes:

Include the range of heights and diameters of the population; vegetation association, i.e., commonest plants growing in the area; and any other general observations you may wish to make that are not covered by the above categories.

Collector:

List the name/names of those who completed this form. If possible, herbarium specimens should be made to document the identification of the plant observed. If you keep a field note book and a series of collection numbers, place the number assigned to the herbarium specimens after the # symbol.

Daniel D. Palmer

LETTER TO THE EDITOR

Dear Editor:

I have read with interest an article on *Andropogon virginicus* in your issue, Vol. 16, No. 1/2.

I think that the date mentioned of about 1932 for the introduction of this plant to Hawaii is in error. According to a letter which I have from the late Dr. Harold L. Lyon dated Oct. 27, 1931, *A. virginicus* was collected on the Kohala Ditch Trail in 1924 and that he had a specimen of it in his herbarium. I am sure that his herbarium was not destroyed upon his death. It may be in either the Bishop Museum or the Lyon Arboretum.

I recall that I collected this grass along the Kohala Ditch Trail in the early 1920's. I do know that by 1932 it was well established in the Kohala District.

I thought you would like to know.

L. W. Bryan, Forester

EDITOR'S NOTE

Index to the Newsletter of Hawaiian Botanical Society Volumes 1-13. By Sarah Wirawan. 17 pages. Price $1.00.

This index to the Hawaiian Botanical Society Newsletter covers volumes 1-13, that is those volumes using the old 8½" x 11" format. The index to subjects and contributors utilizes keywords from titles and contributors only. The index to plant genera includes references in the text of all articles.

The indices are arranged alphabetically. The volume numbers are underlined. Multiple entries in one volume are numbered sequentially without repeating the volume number.

Available from the Secretary, Hawaiian Botanical Society, c/o Department of Botany, 3190 Maile Way, Honolulu, Hawaii, 96822. U.S.A.

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
C/O DEPARTMENT OF BOTANY,
UNIVERSITY OF HAWAII,
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Newsletter Hawaiian Botanical Society

Contents

VOLUME 16 NUMBER 5 DECEMBER 1977

HAROLD L. LYON ARBORETUM
by Robert Hirano 69

THE INFLUENCE OF THE MAJOR FOOD CROPS ON THE SOCIAL SYSTEM OF OLD HAWAI'I
by Isabella A. Abbott 78

HAWAIIAN PLANTS - NOTES AND NEWS
edited by Daniel D. Palmer 73
J. Obata - Colubrina oppositifolia 74
J. Obata - Platanthera holochila 74
J. Obata - Stenogyne kanehoana 74
K. Woolliams - Report from Waimea Arboretum . 75
W. Bush - Croton eluterioides 76
W. Bush - Licania platypus 77

BRIEF REPORTS AND NOTES
SOCIETY BUSINESS...66,67,68; *Stemmermann* - BIRD SNARING...77.

*

Published by the Hawaiian Botanical Society, which was founded in 1924 to "advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership. Information may be obtained from the Society, c/o Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822.

JOINT MEETING OF THE HAWAIIAN BOTANICAL SOCIETY AND THE PACIFIC TROPICAL BOTANICAL GARDEN
OCTOBER 3, 1977

The meeting was called to order at 7:35 p.m. by Vice-President Lani Stemmermann. Forty-three members and five guests were present. Ms. Stemmermann welcomed Steve Montgomery back to Hawai'i, and she also pointed out that Evangeline Funk had brought in basil, lemon grass, and other herbs for anyone who wanted them.

Since this was a joint meeting, the minutes were postponed to the November meeting.

There were announcements concerning the deaths of two of our members. First of all, a letter was received informing the Society that Miss Loraine Kuck passed away on August 9th. Also, the Society was informed that Dr. Haas passed away recently.

In the scientific section of the meeting, John Obata of the Native Plant Committee gave a slide presentation of the various Hawaiian *Scaevolae* including *Scaevola gaudichaudii*. He also asked for more physical and financial support to look for endangered species and to assess the status of these plants.

Following the presentation on *Scaevola*, the program was turned over to Dr. William Theobald. Dr. Theobald introduced Dr. Mathias from U.C.L.A. whose topic was "The Botanical Garden Today." This interesting talk was followed by a 20-minute discussion period. The meeting adjourned for refreshments at 8:40 p.m.

Karen E. Shigematsu, Secretary

MINUTES OF THE REGULAR MEETING OF NOVEMBER 7, 1977

The meeting was called to order at 7:40 p.m. Sixteen members and six guests were present. The minutes of the last two meetings were read by the Secretary and approved as read.

President Ted Green asked whether Dr. Gressitt and the Wau Institute had ever received a donation from the Botanical Society. Since the Secretary reported that the matter was discussed in October 1974, but no action was taken, Ted Green said that he would investigate further.

In New Business, Ted Green had these announcements:

1. Dr. Dan Palmer will be chairman of the Nominating Committee.
2. An Auditor will be appointed to audit the books by December.
3. December will be Plant Donation Month.

Also, the Society was informed that Vice-President Lani Stemmermann will be in the Caroline Islands until January.

In the Scientific Section of the meeting, Dr. St. John introduced Rick Warshauer who found an unrecorded plant on Mauna Kea. Dr. St. John described the plant, *Isoetes*, a completely submerged fresh-water fern ally.

For the Plant of the Month, *Hesperomannia* was discussed by Dr. Palmer.

Then the speaker for the evening, Dr. Yoneo Sagawa, was introduced by President Green. Dr. Sagawa's topic was "Lyon Arboretum: Past, Present, and Future."

The meeting was adjourned at 8:45 p.m.

Karen E. Shigematsu, Secretary

ANNUAL REPORT OF THE SECRETARY FOR 1977

In 1977, the Society members shared in two plant exchanges. During the summer, there was a field trip to Manoa Falls.

The highlights of the year were the botanical programs presented at each of the meetings:

December -- Dr. Gerald Carr gave his Presidential address "Ohikilolo or Bust: The true story of how a biosystematist fell for Hawaii."

January -- Dr. Clifford Smith presented slides and a talk on "Hawaii's National Parks."

February -- At a joint meeting of the Pacific Tropical Botanical Garden and the Hawaiian Botanical Society, Dr. Robert Ornduff was the guest speaker. His topic was "To the High Atlas: Plant Hunting in Morocco."

March -- Dr. Edward Ayensu gave a slide presentation of his "Travels in China."

April -- Mr. Bill Magruder presented "Photographs of Hawaiian Algae."

May -- Mr. Ron Hurov spoke about "Plant Collecting Around the Tropics."

June -- Mr. Art Whistler gave a slide presentation, "Samoa's Scenic Silisili Summit."

October -- Dr. M. Mathias spoke about "The Botanical Garden Today."

November -- Dr. Yoneo Sagawa spoke about "The Lyon Arboretum: Past, Present, and Future."

In addition, a different native plant was featured as "Plant of the Month" during each meeting. Finally, the Trustees of the Marie Neal Trust

Fund allotted $1,000 to be used for a status report on rare and endangered taxa.

Karen E. Shigematsu, Secretary

ANNUAL REPORT OF THE TREASURER

December 1, 1976 - November 30, 1977

RECEIPTS:

Dues and gifts	334.50	
Interest	704.47	
Total receipts		1038.97

EXPENDITURES:

Postage	110.75	
Supplies	81.95	
Prizes (Science Fair)	45.00	
Newsletter	138.56	
Native Plant Project	204.00	
Total expenditures		580.26

NET WORTH OF THE SOCIETY:

Nov. 30, 1976	13,591.17
Nov. 30, 1977	14,049.88

BALANCES IN BANKS:

First Hawaiian Bank Commercial Account

Balance, Nov. 30, 1976	520.72
Deposits, 12/1/76 - 11/30/77	334.50
Withdrawals, 12/1/76 - 11/30/77	(580.26)
Balance, Nov. 30, 1977	274.96

First Federal S & L, Marie C. Neal Account

Balance, Nov. 30, 1976	12,929.23
Interest earned, 12/1/76 - 11/30/77	696.87
Balance, Nov. 30, 1977	13,626.10

First Federal S & L, Savings Account

Balance, Nov. 30, 1976	141.22
Interest earned, 12/1/76 - 11/30/77	7.60
Balance, Nov. 30, 1977	148.82

C. H. Lamoureux, Treasurer

HAROLD L. LYON ARBORETUM

Robert Hirano
Harold L. Lyon Arboretum
University of Hawaii at Manoa

The Harold L. Lyon Arboretum is an organized research unit of the University of Hawaii. It was established in 1918 by the Experiment Station of the Hawaiian Sugar Planters' Association (HSPA) and presented to the University of Hawaii in 1953 with the provision that "The University of Hawaii use, maintain, and preserve the granted premises as an arboretum and botanical garden only." Its boundaries extend from 450 to 1300 feet elevation; the temperature ranges between 52-89°F; and the mean annual rainfall is 160 inches.

When Dr. Harold L. Lyon arrived at HSPA in 1907, grazing cattle had all but completed their conquest over broad areas of upland watersheds vital to the sugar industry in Hawai'i. By 1918, the Experiment Station had acquired the Arboretum property, established a Department of Botany and Forestry under the direction of Dr. Lyon, and charged this department with demonstrating the restoration of rain forest vegetation in denuded watershed areas. Dr. Lyon outlined a broad program that abundantly fulfilled this responsibility and concurrently determined the reforestation values of a large number of tree species. Included were plants of unknown economic potential as well as commercially valuable species as cacao, clove, allspice, cinnamon, camphor and teak. Valuable field collections resulted from the explorations of many collaborators, such as J. F. Rock, who supplied many collections from southeast Asia, and Experiment Station entomologists C. E. Pemberton and F. X. Williams, who supplied a large number of species from the Philippines, Malaysia, New Guinea, New Britain, and Australia. Many collections were obtained by Dr. Lyon himself on visits to the Old and New World tropics.

Once the need for introduction of new forest trees was completed, the Manoa Arboretum had served the purpose for which it was created, but in so doing it had become a vast reservoir of very valuable plant material which could be used to advantage by botanists, foresters, horticulturists, and other researchers. Therefore, in 1953, HSPA decided to grant the facilities to the University of Hawaii. Dr. Lyon served as director of the Arboretum without salary until his death in 1957. The Manoa Arboretum was renamed Harold L. Lyon Arboretum by the University Board of Regents on May 22, 1957.

The Lyon Arboretum is unique as the only tropical arboretum affiliated with a university in the United States. Although the Lyon Arboretum has, since July 1, 1964, been administered as an organized research unit to facilitate research, the goals have gradually been broadened to embrace the promotion, facilitation, and execution of research as well as instruction, and public service as related to its unique resources. The Arboretum facilities include 124 acres of land in upper Manoa Valley 2.5 miles from the campus of the University of Hawaii at Maona, two greenhouses and three office-laboratory buildings. Included in the buildings are offices for personnel, an herbarium of approximately 6,000 voucher specimens, an accession room, a research laboratory, a reference collection, conference and classrooms, and storage areas.

Initial efforts have been directed towards the establishment of plant accessions, updating of records, development of facilities, collections, herbarium, reference materials, and the training of personnel. Future efforts will be directed towards maximizing the effective and efficient utilization of the unique resources of the Arboretum for research, instruction, and service by students, faculty, and staff of the University of Hawaii system, as well as residents of the state of Hawai'i, and an international clientele. Priority will be given to those efforts in consonance with that of the University of Hawaii system, the economy of the state of Hawai'i, the Pacific, Asia, and the tropics, and which capitalize on the diverse ethnic heritage of Hawai'i.

Of high priority is the development and maintenance of a strong program of plant accessions, with emphasis on the flora of Hawai'i, Pacific, Asia and tropics. The approximately 7,000 plant accessions embrace 200 families, 1,000 genera, and 2,300 named taxa. Outstanding are the collections of native and endemic plants of Hawai'i, *Ficus*, palms, taro cultivars, *Calathea*, *Cordyline* (ti), spices, economic and ethnobotanical plants.

Recognition of the importance of the collections and stature of the personnel comes from cooperative efforts of the Lyon Arboretum and the National Cancer Institute for research on natural products of plants. In this cooperative study, natural products are isolated from plants in the Arobretum collections and processed through successive chemical and pharmacological lines of inquiry, the ultimate goal being the development of new drugs. Other inquiries have led to the isolation of biolgoically active or interesting compounds such as a hypotensive agent from *Santalum* by the Department of Pharmacology, University of Hawaii and two new acids from *Oncoba* by the Institute für Technologie und Biochemie (Germany) named "oncobic acid" after the plant genus and "manoaic acid" after beautiful Manoa Valley. Efforts have also been directed towards the evaluation and isolation, from our vast plant collections, of taxa which show promise as new introductions to Hawaii's growing commercial plant industries.

The arboretum also serves as a unique site for researchers in a broad spectrum of scientific disciplines and agencies: entomology, for studies of the coffee twig borer; civil engineering, for studies of solar radiation and the quality of cesspool leachates; food technology, for studies of alternative methods for processing taro; medicine, for studies on reproductive biology; botany, for studies on post-harvest physiology of tropical fruits; the soil sciences, for studies on water retention and percolation and water quality; the United States Department of Agriculture, for studies on a newly introduced moth *Macroglossum*; and Kuakini Hospital for studies on allergy to spores and pollen.

The annual *Harold L. Lyon Arboretum Lecture; Lyonia*, an occasional paper series of the Lyon Arboretum; occasional checklists of plant collections at the Arboretum; a seed exchange list; and a summer seminar series as sponsored by the Lyon Arboretum serve to enrich the academic environment as well as to focus on the opportunities in the Pacific area. These have gained wide attention and have resulted in distribution to an international audience serving as a basis for our exchange program.

In addition to research, the Arboretum contributes wide-ranging support to the teaching programs of a broad spectrum of departments in the University of Hawaii system as well as students from pre-school through high school and adults from the public and private sectors who benefit from instructional support services and on site instruction. A program of summer traineeships has been established to provide opportunities for undergraduates to experience the diversity of the Arboretum. In addition, opportunities have been extended to undergraduates in plant sciences to fulfill their requirements for summer practicum at the Arboretum with credit earned as Horticulture 490.

In order to meet the demands of an ever increasing clientele, the Lyon Arboretum Association has been organized as a non-profit community support group. Association members have provided both financial and volunteer support. Volunteers have assisted in the greenhouse, office, on the grounds and as tour guides and instructors. Because of their support, the education program at Lyon has flourished. Today, sessions of courses are offered four times a year; winter, spring, summer and fall. In addition, special workshops are scheduled throughout the year.

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Yoneo Sagawa, Director, 1967 - present
Donald Anderson, Research Associate (Retired)
Robert Hirano, Assistant Researcher
Hugo Kortschak, Research Affiliate
Beatrice Krauss, Research Affiliate
Kenneth Nagata, Research Associate
Dorothy Niimoto, Research Affiliate
Glen Spence, Research Associate
David Shearard, Research Associate
Marjorie Whiting, Research Affiliate

Past Director

Dr. George Gillett, 1964-1967

Publications of Harold L. Lyon Arboretum

University of Hawaii
3860 Manoa Road
Honolulu, Hawaii 96822

Harold L. Lyon Arboretum Lecture Series (annual):

Number One: The Pacific as a Key to Flowering Plant History. Albert C. Smith. 28 pp. 1970. $5.00

Number Two: The Ecology of Drosophila Breeding Sites. Hampton L. Carson. 28 pp. 1971. $5.00

Number Three: The Embryo Sac and Fertilization in Angiosperms. William A. Jensen. 32 pp. 1972. $5.00

Number Four: Mechanism of Translocation in Sugarcane. Constance E. Hartt. 40 pp. 1973. $5.00

Number Five: Ethnobotany of the Hawaiians. Beatrice H. Krauss. 32 pp. 1975. $5.00

Number Six: The Diversity and History of Polynesian *Bidens*, Section Campylotheca. George W. Gillett. 32 pp. 1975. $5.00

Number Seven: Life and the Wonders of Water. Harry F. Clements. 32 pp. 1976. $5.00

Number Eight: The Prospect for Mycology in the Central Pacific. Gladys E. Baker. 51 pp. 1977. $5.00

Checklists:

The Taro Collection, Checklist of Taro Cultivars [*Colocasia esculenta* (L.) Schott] in Harold L. Lyon Arboretum. July 1, 1970. 8 pp. [Not available]

A Checklist of Palms in the Harold L. Lyon Arboretum. July 1, 1970. 24 pp. $1.00

A Checklist of Indigenous and Endemic Plants of Hawaii in Cultivation at the Harold L. Lyon Arboretum. Robert T. Hirano and Kenneth M. Nagata. January 1, 1972. 38 pp. with Addenda to June 30, 1977. $1.00

A Checklist of *Ficus* (Moraceae) in the Harold L. Lyon Arboretum. Kenneth M. Nagata and Robert T. Hirano. December 15, 1972. 12 pp. with Addenda to June 30, 1977. $1.00

Lyonia (occasional papers):

Checklist of Hawaiian Mosses. W. J. Hoe. Vol. I, No. 1. 45 pp. 1974. $3.00

The Pacific Species of *Ophiorrhiza* L. (Rubiaceae). Stephen P. Darwin. Vol. I, No. 2. 56 pp. 1976. $5.00

Psychotria L. in the Hawaiian Islands. S. H. Sohmer. Vol. I, No. 3. 83 pp. 1977. $9.00

Newsletter (quarterly):

Kukui Leaf, Newsletter of Lyon Arboretum Association.

HAWAIIAN PLANTS - NOTES AND NEWS

This is a new column for our newsletter. It will contain formal or informal reports concerning both native and introduced plants.

The section on native plants will contain information of significant interest including reports on the distribution of rare Hawaiian plants, rediscoveries of species considered extinct, new localities for plants with limited range, notes regarding the discovery of new species, reports on the disappearance or destruction of a population of plants, reports on the phenology of rare plants (flowering time and fruiting time), and other material of interest.

The section on introduced plants (exotics) will contain information regarding new introductions, notes on the location of uncommon or unusual plants, reports on weed plants or plants that are likely to become weeds, notes on plants of unusual beauty, size or character and any other information regarding exotic plants that might be of interest to our readers.

The editor of this column will serve as a clearing center for information and will make it as easy as possible for contributors. A simple note or even a phone call will be all that is needed for a short report. Longer more formal reports will be welcome but should be presented in manuscript.

Information for future issues is now needed.

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1975 Judd Hillside,
Honolulu, Hawaii 96822.
phone: 946-6084

NATIVE PLANTS

Regeneration of *Colubrina oppositifolia* Brogn. ex Mann (Kauila)

Because of the lack of regeneration, many feel that Hawaii's kauila will become extinct when the present surviving plants die. On January 8, 1978, three healthy seedlings were observed in Makaleha Valley, Wai'anae, O'ahu. They were growing under a canopy of native plants and on a well drained 45 degree slope. This regeneration is in spite of two rather dry seasons experienced on O'ahu. Hopefully these and some other cultivated clones may survive the ravages of modern day "contaminated" environment.

J. Obata

A recent collection of *Platanthera holochila*

During the August 31 to September 4, 1977 field trip to Alaka'i Swamp and Wai'ale'ale, Kaua'i by the Bishop Museum's Botany Department's staff, the rare endemic Hawaiian orchid, *Platanthera holochila* (Hbd.) Krzl. was observed. (This species is also known as *Habenaria holochila* Hbd.) The last time this species seems to have been seen and collected was during the late 1930's. Degener, Fosberg, Hosaka, Neal, Piersall, St. John, and others have observed and collected vouchers during this period from Kaua'i, O'ahu, Moloka'i and Maui.

Dr. Pieter van Royen found these plants growing in a large bog in the Alaka'i Swamp. They were described as "eight plants seen were growing on a raised hummock of fine organic mould." Members of the field trip besides Dr. van Royen of the Bishop Museum were Joyce Davis, curatorial assistant of the Bishop Museum and Steve Pearlman of the Pacific Tropical Botanical Garden. Vouchers were taken and deposited at the Bishop Museum.

J. Obata (As described by van Royen
Davis)

Stenogyne kanehoana Deg. & Sherff in Sherff

On January 8, 1978, Alan Hart, an artist-malacologist, and Omer Bussen, an ornithologist-school teacher, stumbled on to a plant which they could not identify, but its beauty captivated them. Thinking that it was a rather handsome exotic, a small voucher was taken as an after-thought just for the sake of identification. Later it was determined as *Stenogyne kanehoana*, a rather rare Hawaiian endemic today.

Through some unexplained oversight, this plant was not listed in the Federal Register of endangered plants. In fact, this *Stenogyne* is much more endangered than practically all the other plants listed as endangered from Hawai'i.

A field survey was made on January 29, 1978 to record the status of this plant in the southern Wai'anae Range of O'ahu. The result was possibly three intertwining lianas climbing and crawling over nearby vegetations. The colony area was rather restricted, 4 by 10 meters. One vine climbed to a height of about four meters. The flower may be described as a giant among *Stenogyne*. The corolla when fully matured measured 6.5 cm (2.5 inches) long and 2.5 cm (1 in.) wide. Corolla color was off white and corolla lobes pink.

J. Obata

REPORT FROM WAIMEA ARBORETUM

Endangered Species at Waimea Arboretum

Sophora chrysophylla var. *kauensis* Chock (W.A.74s1758). "māmame"; "mamamo" Herbst & Ishikawa 5067. Collected Ocean View Estates, Hawai'i.

Propagation: October 31st. 1974; 41 seeds sown; hot water treated.
November 15th. 1974; 1 germinated.
January 3rd. 1975; 7 potted plus several more later.
November 1975: 11 planted in Hawaiian Flora Collection.

Notes: This species has never made any spectacular growth. More often than not the leaves were showing iron deficiency. During summer of 1977 foliar feeding with iron was carried out and general improvement in condition was immediate.

Flowering: The first flowers appeared in March 1978, accompanied by quite a lot of new basal growth. Flowers are pure yellow and quite attractive.

Mezoneuron kavaiense (Mann) Hbd. "uhiuhi"; "kea"; "kalamona"
Seeds from Derral Herbst, collected Pu'uwa'awa'a, Hawai'i (same as Herbst 1177).

Propagation: October 1st. 1974; 9 seeds sown.
October 17th. 1974; 1 germinated.
October 30th. 1974; 2 potted.
A further sowing was made from seeds stored in refrigerator.
October 30th. 1974; 5 sown filed.
November 12th. 1974; 3 germinated.
December 4th. 1974; 5 potted.
June 1975: 7 planted in Hawaiian Flora Collection.

Notes: Frequently attacked by borers, mainly in upper 1-2 ft. of growth. Re-growth soon replaces lost branches. Insecticides not tried. Iron deficiency commonly noted and applications of iron as foliar feed in 1977 beneficial.

Cuttings have been tried, but never rooted.

Flowering: First flowers appeared in February 1978.

Lepechinia hastata (Gray) Epling. "pakaha"
Seeds from Kula Experimental Station, Maui, collected by Dr. Powers on road to Haleakalā National Park, Maui. Elevation 6200 ft.

Propagation: Seeds germinate easily and present no problems until planted in the grounds, where they usually live only 2 or 3 years. Cuttings taken from late summer to early autumn root readily, especially short 'heel' cuttings from the lower part of the plant.

Notes: Subject to soil-borne fungi. Results at Waimea have shown that this plant responds well to high phosphate applications which appears to reduce susceptibility to such attacks, probably due to the stronger root system.

A plant from the southern tip of Baja, California known as *Sphacele hastata* Gray may be the same species. To date, attempts to obtain material of this for comparative growth tests have been unsuccessful. If this is, in fact, the same species, it would explain why a plant from 6200 ft. on Haleakalā would do so well at sea level at Waimea!

Flowering: Main flowering is during summer (at Waimea) but some flowers are usually apparent during winter months too.

Keith Woolliams

EXOTIC PLANTS

Croton eluterioides Lotsy.

Alongside an old greenhouse near the Firelane on the University of Hawaii campus are several shrubby trees with heart-shaped leaves, rather insignificant whitish flowers and fruiting capsules about an inch in diameter and spiny on the outside like castor-bean fruits. Inquiries on the campus got the writer nowhere but specimens sent to Dr. Frederick G. Meyer, Supervisory Botanist, National Arboretum Herbarium, were in turn sent by him to a specialist in the Euphorbiaceae at Kew Gardens. Because it was a New World species Mr. H. K. Airy Shaw turned it over to a colleague to make the determination. Kew had an isotype specimen which matched the University specimen perfectly. The riddle is how did *Croton eluterioides* Lotsy, a Guatemalan endemic, get to Hawai'i? So far as the writer knows this is the only *Croton* growing in Hawai'i.

William M. Bush

Licania platypus (Hemsl.) Fritsch.

Another interesting tree on the University campus is growing on the Diamond Head side of Sinclair Library. While at present only about 20 feet high, Standley in *Flora of the Panama Canal Zone* describes *Licania platypus* (Hemsl.) Fritsch. as a handsome tree of great size. He states that the fruits which get quite large (15 cm) take at least a year for full development.

William M. Bush

BIRD SNARING

R. Lani Stemmermann
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Recently two instances of bird snaring by native plants have been brought to my attention. On 1 August 1977, in East Maui between Wai'ānapanapa and Waieleele in the company of Dr. Gerald Carr and Mr. Alain Meyrat from the University of Hawaii Department of Botany, I found a Leiothrix (*Leiothrix lutea*) caught by *Uncinia uncinata*. We were in the area looking for *Dubautia*, and were walking along the trail when we heard a frenzied chatter in the underbrush. Upon investigating we found the ensnared Leiothrix with an inflorescence attached to each wing. The bird was alive and struggling, but could not free itself. In its struggle it had also become tangled in a fern.

Uncinia uncinata (L. f.) Kuek. (Cyperaceae) is not uncommon in the wet forests of E. Maui. Its inflorescence consists of many small florets arranged in a congested spike of about 4-10 inches in length. Each floret is armed with an awn with a retrorse hook. These hooks become attached to anything with which they come into contact and can be rather painful on bare skin. The barbed inflorescence was attached lengthwise to the wings of the Leiothrix so that both the primaries and secondary wing feathers were caught. The bird was ensnared by the sedge so firmly that I was able to lift it by one of the inflorescences.

Degener (1930, Ferns and Flowering Plants of Hawaii National Park) reports that *Uncinia* seeds readily catch onto the feathers of birds, and are dispersed in this manner, but I know of no instance where actual snaring has been reported. It is probable that birds, such as the Leiothrix, that frequent the understory where *Uncinia* is found could periodically get ensnared in such a manner.

The other instance of a plant trapping a bird was brought to my attention by Evangeline Funk, a graduate student at the University of Hawaii Botany Department. While in the back of Waihole Valley on 13 August 1977, she came across a dead bird (later identified as a fledgling Shama Thrush, *Copsychus malabaricus*, by Maile Stemmermann) caught in the sticky fruits of *Pisonia*, pāpala-kēpau. The stickiness of the fruits allows them to be dispersed when caught on the wing or feathers of birds, but when a small bird gets caught in an entire inflorescence of these fruits, it may not be able to free itself. The Hawaiians used the fruits of the pāpala-kēpau as bird lime to trap birds for their featherwork (Rock 1913, Indigenous Trees of the Hawaiian Islands), and often feathers are seen on the fruits of this plant, but one usually does not find birds captured in the inflorescence.

THE INFLUENCE OF THE MAJOR FOOD CROPS ON THE SOCIAL SYSTEM OF OLD HAWAI'I

Isabella A. Abbott
Wilder Professor of Botany, UHM
Professor of Biology, Stanford University

The botanical or horticultural evidence from the cultivation of taro, *Colocasia esculenta* (Linne) Schott, by early Hawaiians supports the hypothesis that these Polynesians came from lands where taro was a principal crop, and that this plant must have come early with these voyagers since a large number of cultivars are available. A large number of myths and legends (Beckwith, 1940) surrounding this plant are known.

The number of named taro varieties is larger in Hawai'i than in any other part of the Pacific and though many varieties were probably not used for the production of poi, the Hawaiian staple, they may have been retained for their attractiveness. Only 3 or 4 varieties are used commercially for poi or luau at this time, although stock for about 85 varieties is available at the Keanae Botanical Garden on Maui and the Lyon Arboretum in Manoa Valley. This stock constitutes the remaining varieties of what has been estimated (Handy, 1940; Handy & Handy, 1972) to be 300-343 cultivars of taro named by the Hawaiians. The majority of Hawaiian taro is propagated vegetatively, although there are some varieties that bear flowers and set seeds. Even to unpracticed eyes, many of these plants are spectacular in their differing colors shown by petioles (scarlet, black, or green), leaves (green, smokey, speckled, or with colored veins) and corms (white, gray, reddish, or lavender).

The ethnological evidence in the form of myths and legends upon which religion, planting methods and to a large degree the social system of old Hawai'i was based is compelling. No other plant, not even sweet potato whose cultivation was widespread in Hawai'i, had such a strong influence on the development of the maka'āinana, the Hawaiian planter.

In numbers in pre-Cook times, the maka'āinana may have represented about 75% of the population, estimated by Cook to be about 50,000 at Kealakekua. By his activities, the maka'āinana supported in food and fiber the ali'i of various levels, representing about 24% of the population. The remaining 1% were the kauwā, a class of outcasts about which little is known, and who were in any case forced to fend for themselves. In return for his labor, the maka'āinana could use the land belonging to the ali'i for taro growing, and could also use the water upon which wetland taro depended. For upland or dry-land taro and sweet potato cultivation where running water was not critical, he could add olonā, wauke, māmaki and other fiber plants to his "farm." Each year during the Makihiki season (roughly the end of September to the end of January), he would give to the ali'i a share of food and fiber as an offering to the god Lono. At other times, he was able to exchange these items with his extended family, 'ohana, from the uplands or coastal areas.

The god Kāne, who was to the Hawaiians and some other Polynesians the giver of life, was the chief god of the taro planter. It was to him that prayers on planting and harvesting were directed, and for whom sacred or kapu planting days were set aside. Other major gods, Ku, Kanaloa and Lono were also worshipped. Definite plants were associated with these gods: taro with Kāne, breadfruit and coconut with Ku, banana with Kanaloa and sweet potato with Lono. Propitiations to these gods assured good crops, and the kapu days set aside for each one established a planting routine and practices which persisted long after the gods were abolished by Queen and Regent Ka'ahumanu in 1819.

Sinoto of the Bishop Museum has shown that Hawaiian fish hooks and adzes are very closely related in form and material to those from the Marquesas. On this basis he relates the early Hawaiians to the Marquesans. From the viewpoint of ethnobotany, however, it should be stated that the Marquesans were breadfruit specialists, having about 200 named varieties (Brown, 1935) in contrast to the one variety that the Hawaiians had. The number of taro varieties used by Marquesans was low. Handy (1972) suggests that the topography of the islands, steeper and lacking the valleys of Hawai'i is not as suitable for taro culture as is Hawai'i, where he estimated as much as 10 square miles utilized for this purpose on Hawai'i Island alone.

While it is difficult if not impossible to reconstruct the early Polynesian migrations and settlement of Hawai'i, it seems clear that the successful early settlers brought taro with them. Their development of this primary food source resulted in isolating a large number of cultivars adapted to diverse habitats. These are a biological legacy perhaps more informative of pre-contact Hawai'i than any other major remnant of old Hawai'i.

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edited by

CLIFFORD W. SMITH

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ARTICLES AND NOTES

Page

ABBOTT, I. A.: The Influence of the Major Food Crops on the Social System of Old Hawaii . . . 78
Andropogon virginicus (Broomsedge) (James Sorensen) . . . 7
Andropogon (Letter to the Editor) . . . 63
Bird Snaring (R. L. Stemmermann) . . . 77
Broomsedge (James Sorensen) . . . 7
BUSH, W.: *Croton eluterioides* . . . 76
BUSH, W.: *Licania platypus* . . . 77
Colubrina oppositifolia (J. Obata) . . . 73
Croton eluterioides (W. Bush) . . . 76
Development of Emergent Vegetation in a Tropical Marsh (Kawainui, O'ahu) (Linda L. Smith) . . . 37
Editor's Note . . . 6, 63
Endangered Hawaiian Plants (Derral Herbst) . . . 22
Food Crops on the Social System of Old Hawaii, Influence of (I. A. Abbott) . . . 78
Hawaii Volcanoes National Park--Kalapana Extension (F. R. Warshauer) . . . 57
Hawaiian Plants - News and Notes . . . 73, 74, 75, 76, 77
HERBST, D.: Endangered Hawaiian Plants . . . 22
HIRANO, R.: Harold L. Lyon Arboretum . . . 69
HOE, W. J.: Review of H. O. Whittier: Mosses of the Society Islands . . . 5
Kalapana Extension of Hawaii Volcanoes National Park: Its Variety, Vegetation and Value (F. R. Warshauer) . . . 57
Kānepu'u Dryland Forest - Use and Knowledge of by Lāna'i Residents . . . 4
Kawainui, O'ahu (L. L. Smith) . . . 37
Letter to the Editor . . . 63
Licania platypus (W. Bush) . . . 77
Lyon Arboretum (R. Hirano) . . . 69
MONTGOMERY, S. L.: Use and Knowledge of the Kānepu'u Dryland Forest by Lāna'i Residents . . . 4
Native Plant Committee Report (D. Palmer) . . . 60
OBATA, J.: *Colubrina oppositifolia* . . . 73
OBATA, J.: *Platanthera holochila* . . . 74
OBATA, J.: *Stenogyne kanehoana* . . . 74
PALMER, D.: Report of the Native Plant Committee . . . 60
Platanthera holochila (J. Obata) . . . 74
SMITH, L. L.: Development of Emergent Vegetation in a Tropical Marsh (Kawainui, O'ahu) . . . 37
Social System of Old Hawaii, Influence of the Major Food Crops on (I. A. Abbott) . . . 78

Page

Society Business 2, 3, 29, 30, 32, 34, 35, 36, 66, 67, 68
SORENSEN, J.: *Andropogon virginicus* (Broomsedge) 7
STEMMERMANN, R. L.: Bird Snaring 77
Stenogyne kanehoana (J. Obata) 74
Waimea Arboretum Report (K. Woolliams) 75
WARSHAUER, F. R.: The Kalapana Extension of Hawaii Volcanoes National Park: Its Variety, Vegetation, and Value 57
Whittier, H. O. (Mosses of the Society Islands, reviewed by W. J. Hoe) 5
WOOLLIAMS, K.: Report from Waimea Arboretum 75

REVIEWERS OF ARTICLES

appearing in Volume 16 (1977)

Carr, G. D.
Hoe, W. J.
Lamoureux, C. H.
Mueller-Dombois, D.
Stemmermann, R. L.

All views expressed in signed articles are those of their author(s) and do not necessarily reflect opinions or positions of the Society.

Scientific Name Common Name Hawaiian Name

Pandanus spp. (con't.)

Preparation method: Leaves, either fresh or dry, were stripped of their sharp edges and spines, softened by drawing them over a sharp edge, cut into strips of varying widths and then plaited. The bracts of male inflorescence were prepared in this way and used for fine plaiting. The dried keys were used as paint brushes (2,3,5,6,7,9, 11,12).

Pipturus albidus (H. & A.) Gray in Mann Mamaki

Uses: Inner bark of *Pipturus* is said to have been used for tapa.

Preparation method: Fibers were obtained by retting. Other preparation methods have been reported, but they are unclear (3,4,5,6,10,11).

Pritchardia gaudichaudii (Mart) H. Wendl. Fan Palm Loulu

Uses: Leaves were woven into baskets, hats and bed mats.

Preparation method: Unknown (3,5,6,9,12).

Rubus macraei Gray Blackberry Akala

Uses: It has been reported that "Akala" was used for tapa making.

Preparation method: Unclear (4,5,9,10,11).

Sacchurum officinarum L. Sugar Cane Ko

Uses: Leaves of sugar cane were used for thatch and fibers from the inflorescence were used for braid.

Preparation method: Unknown (3,5,8,11,12).

Sadleria cyatheoides Kaulf. Pulu 'ama'u

Uses: Fronds were used as finish trim on lauhala thatch of some Hawaiian houses. Stems were used for plaiting, for baskets and fish traps.

Preparation method: Unknown (5,6,9,11,12).

Scientific Name	Common Name	Hawaiian Name
Scirpus validus Vahl	Bulrush	Aka'akai

Uses: Stems were used for house thatch and for mats used for the lower layers of sleeping couches. Temporary mats were made for wrapping dead bodies. The material was not durable.

Preparation method: Unknown (3,5,9,12).

Thespesia populnea (L.)		Milo

Uses: Fibers from the inner bark were used for tapa and fine cordage.

Preparation method: Usable material was obtained by retting (4,6,9,10, 12).

Touchardia latifolia Gaud.		Olona

Uses: Fibers were used for fish lines, strangling cords, ropes, to tie feathers to capes and helmets, to make feather leis, shell leis, handles for daggers and clubs and many other uses.

Preparation method: Fiber was obtained from inner bark by retting in running water (1,2,3,4,5,9,11,12).

Urera sandwicensis (H. & A.) Wedd.		Opuhe

Uses: Fiber used for making fish nets. Some writers have said that the fibers from *Urera* were used for the same purposes as those of *Touchardia*.

Preparation method: Fiber was extracted from the inner bark by retting (9,12).

Wikstroemia spp. Endl.	False 'Ohelo	Akia

Uses: Used for tying. No specific use.

Preparation method: None.

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Contents

VOLUME 17 NUMBER 1/2 FEBRUARY/APRIL 1978

DEVELOPMENT OF EMERGENT VEGETATION IN A TROPICAL MARSH (KAWAINUI, O'AHU) 2

HAWAIIAN FIBER PLANTS 27

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DEVELOPMENT OF EMERGENT VEGETATION IN A TROPICAL MARSH (KAWAINUI, O'AHU)*

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Introduction

This study examines the historical development and present distribution of plant species in a tropical lowland marsh. As with many other wetlands, the eventual use of this marsh has been the subject of public controversy. In August of 1975, a fire, which burned for several days, focused public attention on the marsh.

This study was undertaken to obtain baseline data on the vegetation of the marsh and to determine the major influences which have led to the development of the marsh as it is today. It was hoped that these studies would provide information useful in land-use management decisions.

Preliminary reconnaissance and examination of historical information led to the hypothesis that there are two vegetation types in the marsh, one in the drier parts of the marsh, composed almost entirely of an introduced grass species, and one in the ponding basin, composed of both native and introduced plant species. These ideas led, in turn, to examination of past water management and agricultural practices which might have determined the present character of the marsh.

A preliminary study of productivities and nutrient fluxes was conducted in order to obtain a rough idea of the role of the marsh in the Maunawili Valley watershed.

Area Description

Kawainui Marsh is an area of about 280 ha lying in Maunawili Valley between the foothills of the Ko'olau Mountains and Kailua Bay on windward O'ahu, Hawaiian Islands. The marsh is fed by two streams and debouches into Kailua Bay via Kawainui Canal.

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* This is the second of two articles on the Kawainui marsh. The study fulfilled part of the requirement for the M.S. degree in Botany at the University of Hawaii.

This work was partially supported by the Water Resources Research Center, University of Hawaii and by the Department of Parks and Recreation, City and County of Honolulu. Thanks are extended to T. Minnick for his assistance with field and laboratory work, also to S. V. Smith for his valuable suggestions and criticisms.

Water Resources Research Center Contribution No. 110.

The marsh receives secondarily-treated effluent from four sewage treatment plants which were built between 1957 and 1965. It also receives runoff from a sanitary landfill and two housing subdivisions.

Preliminary estimates made from stream-flow and rainfall data (Takasaki *et al.* 1969, Blumenstock 1961, respectively) indicate that the marsh has a total water budget of about 36,000 m^3 per day with perhaps 12,000 m^3 per day accounted for by evapotranspiration and the remainder exiting via the canal.

The climate is tropical with a wet winter and a dry summer. Mean annual rainfall is 1,050 mm; mean annual temperature is 24°C; relative humidity is 70 to 80 percent; and mean annual insolation is 3,800 kcal per m^2 per day.

Preliminary estimates of net primary productivity and nutrient fluxes through the system suggest that the marsh is highly productive (up to 48 mt per ha per yr dry weight of plant matter, or about 1% solar efficiency) and that it plays an important role in the watershed of Maunawili Valley by stripping the water column of nutrients. However, it must be emphasized that these estimates, as well as the abovementioned water budget are preliminary.

Methods

Ground and aerial reconnaissance surveys were made. Comparisons were made with aerial photographs for mapping vegetation. Plant collections were made in the marsh and its periphery. These collections are in the herbarium of the Botany Department of the University of Hawaii (HAW).

Transects were established across the two vegetation types. The grass community was so obviously uniform that no detailed transecting was attempted.

Five transects were placed in the bulrush community at right angles to the Kailua levee. Braun-Blanquet cover/abundance estimates (Mueller-Dombois and Ellenberg 1975) were made at 10-m intervals. The entire marsh is difficult to traverse. Most of the ponding basin is impassable; only short transects from shore were possible.

The search for historical records led to governmental and private organizations as well as to private individuals. There is little published material on the area; therefore, this study relies more than is usual on interviews and unpublished reports. Some of the cited material is publicly available. Some is not and remains only as conserved by individuals.

Aerial photographs were examined to determine the areal extent of the two vegetation types through time. Two methods were used: (1) documents were photocopied and the areas of interest cut-out and weighed, and

(2) the areas of interest were traced on 10 x 10-cm graph paper and the areal extent estimated by counting grid squares. Method 1 was used for estimating the area of vegetation types; these were relatively large areas. Method 2 was used for estimating the areas of open water; these consisted of many small, discrete units which did not lend themselves to estimation by method 1.

Results

Plant Species Distribution

There are two main vegetation types in the Kawainui marsh; a bulrush community and a grass community. No detailed transects were placed in the grass community, although the area was thoroughly covered on foot. Five transects were placed at right angles to the levee in the bulrush community; the results are shown in Table 1.

Figure 1 is a schematic presentation of a profile of the marsh. The plant communities shown are a composite of an idealized line across the marsh rather than a detailed rendering of an actual transect. The profile of the substratum is drawn from information contained in a report by Dames and Moore, Inc. (1961).

The grass community occurs in the upper, mountainward portion of the marsh on alluvial soils. This is an almost pure stand of *Brachiaria mutica*. There are some small intrusions of bulrush where low spots create a situation of permanently standing water.

Typha latifolia occurs in the bulrush community as pure stands 5 to 20 m across. These stands are conspicuous in the field but comprise less than 1 percent of the total community and could not be mapped with the methods available.

Sagittaria sagittaefolia occurs near the large lake. In one small area (about 1,000 m^2) *Sagittaria* composes almost 50 percent of the plant cover. This plant is evident only during the wet season. A species of *Xanthosoma* was found sparsely to rarely near the streams at the upper end of the marsh. *Ludwigia octovalvis* was found along the banks of these streams.

One specimen of *Ficus microcarpa* was found growing near the large lake in a hummock of *Brachiaria* and was the only large woody plant found in the grass community.

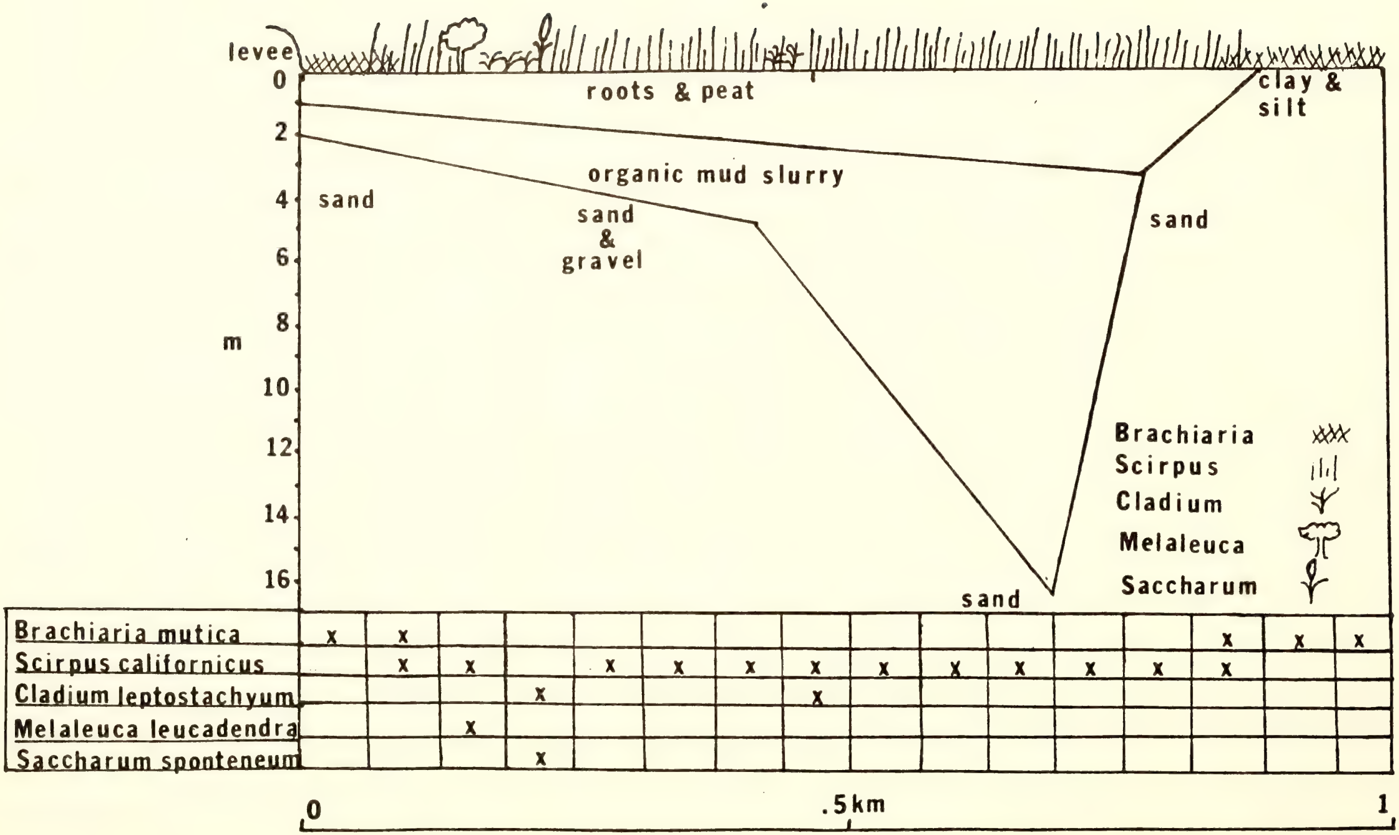
The community which overlies the ponding basin is dominated by the bulrush *Scirpus californicus*. *Brachiaria* intrudes into this community as a transition zone phenomenon.

The second most dominant plant in this community is the sawgrass *Cladium leptostachyum*. It occurs as discrete patches and to some extent intermingled with *Scirpus*.

Table 1. Transects through the bulrush community. *Cladium leptostachyum* is over-represented because of impassibility through pure stands of this plant. Transects terminated in these stands. Because the transects were short, *Cladium* assumed a large proportionality. Percent cover estimated on Braun-Blanquet cover/abundance scale* (Mueller-Dombois and Ellenberg 1974).

	Transect	1		2		3										4											5										
SPECIES	10-m Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Brachiaria mutica			2			5	5	4								3				3	3	3	3	3	3	3	3	1	1	2	1	1	1	1			
Saccharum sponteneum													1																								
Scirpus claiformicus		1	4	1				4			3	3	3			4	3					3	3	3	3	3	3			3	5	5	5	5	4	4	4
Cladium leptostachyum		1	4	1	5				4	5	4	4	5	5	5		4	5	5	3	3	3	3	3	3	3		5	5	3					2	3	3
Cyperus alternifolius											r					3																					
Cyclosorus interruptus		5		5	2			2	3				2									2	2	2	2	2											
Commelina diffusa		1		1																							+										
Eichhornia crassipes														r																							
Ludwigia octovalvis		1		+																																	
Pluchea symphytifolia		+		+														+	+								+	+									
Pluchea indica						r																															
Melaleuca leucadendra					1	1							1																								
Schinus terebinthifolius						r																															

*Explanation of cover/abundance scale: 5 = any number with cover more than 75%; 4 = any number, cover 50-75%; 3 = any number, cover 25-50%; 2 = any number, cover 5-25%; 1 = numerous, less than 5% cover; + = numerous, small cover; r = solitary with small cover.


levee
0
2
4
6
8
10
12
14
16
m
roots & peat
organic mud slurry
sand
sand & gravel
sand
sand
clay & silt
Brachiaria
Scirpus
Cladium
Melaleuca
Saccharum
0
.5km
1

Brachiaria mutica	x	x												x	x	x
Scirpus californicus		x	x		x	x	x	x	x	x	x	x	x	x		
Cladium leptostachyum				x				x								
Melaleuca leucadendra			x													
Saccharum sponteneum				x												

Figure 1. Profile diagram of Kawainui Marsh. The vegetation profile is an idealized section 1 km long, taken from the Kailua levee to Quarry Road. The stratigraphic section is drawn from information contained in a report by Dames and Moore, Inc. (1961).

The bulrush forms thick mats of roots and living material which are substantial enough to walk on. The sawgrass, however, forms mats which are too thin to walk on and which can only be traversed with great difficulty in what is known in the U. S. Army as low-crawl (i.e., prone with arms out-stretched). This method is only successful in the thicker portions of the sawgrass. Pure stands of sawgrass presented impassable zones when transects were made from the Kailua levee, thus preventing any direct ground observations of the central portion of the marsh. In addition, an artifact of this difficulty is that the sawgrass is greatly over-represented in the transect data (Table 1) as the short transects terminated in stands of sawgrass.

Two species which represent an insignificant amount of cover, but which are conspicuous in the field are the paperbark tree, *Melaleuca leucadendra*, and wild sugarcane, *Saccharum spontaneum*. There are about 30 paperbark trees and 10 stands of sugarcane located near the Kailua levee. These plants are rooted in mats of *Scirpus* and *Cladium* which are floating on a slurry of organic mud.

The taro patch fern, *Cyclosorus interruptus*, occurs throughout the community and in one small area (about 12 m across) forms an almost pure stand. This plant forms a substantial mat over a slurry.

That the substratum was a floating mat of vegetation over a slurry was confirmed not only by the Dames and Moore, Inc. (1961) report, but also by inserting a stick with a notched end into the root masses while conducting transects. One could feel when the stick broke through the root masses and peat. Sediment samples could be taken occasionally from a notch in the stick by twisting it before pulling it out.

Water hyacinth, *Eichhornia crassipes*, occurs rarely among the bulrushes. It is most conspicuous in a small pond (about 5 x 10 m) near Kailua Road, where it occasionally forms a complete cover.

Other species which were found in the floating mats are listed in Table 1 along with an estimate of percent cover. A list of all plant species found in the marsh and in the peripheral areas is given in Appendix 1.

After a fire in August of 1975, about 60 paperbark seedlings were found at the foot of two paperbark trees in the bulrush community. By June of 1976 no seedlings could be found. These areas were occupied by sawgrass and taro patch fern.

Historical Development of the Marsh

In terms of management, the area has gone through five distinct phases. Prior to the arrival of the Polynesians, the area of the ponding basin may have looked much as it does now. The sawgrass is native to Hawai'i. The bulrush or a very similar species of *Scirpus* was certainly present at a very early date, as evidenced by an 1851 map. The drier portion of the marsh may have been a thicket of *Hibiscus tiliaceus*, with some native sedges, and possibly *Sesuvium portulacastrum* and *Bacopa monnieri*. This is, of course, pure speculation based only on the nature of the habitat (probably brackish) and knowledge of the native plants which might have been present.

The Hawaiians used the ponding basin as a fishpond and the higher areas for taro farming (McAllister 1933), so that the portion of the marsh which is now covered by *Brachiaria* was in taro cultivation. The area now occupied by the bulrush community was open water, kept so by massive efforts to clean out the vegetation once a year (Summers 1964, McAllister 1933). Areas below the marsh and between it and Ka'elepulu Pond were also in taro. There was a system of drainage such that water first entered the upper taro patches, flowed into the fishpond, through the lower taro patches, and into Ka'elepulu Pond. When the lower taro patches were being dried a ditch diverted water directly into Ka'elepulu Pond (McAllister 1933).

The area was probably a brackish water environment during both of these phases. There is evidence of saltwater intrusion in Kawainui Stream, which parallels the Kailua levee. Halophytes such as *Sporobolus virginicus* grow along this stream. During one period in 1977, the salinity of this stream was measured to be $18^{\circ}/_{\circ\circ}$. At that time the sandbar had been cleared from the mouth of Ka'elepulu Stream and the direction of flow in Kawainui and Ka'elepulu Streams was under tidal control.

McAllister (1933) reported that brackishness was encouraged by the Hawaiians where fishponds lay near the sea and that they tended to keep the mouths of such streams cleared to allow saltwater intrusion of the fishponds.

The third phase in the development of the marsh came with the arrival of the Europeans in Hawai'i. Maintenance of the fishpond required the efforts of the entire population of nearby areas for three days each year. The organization of these efforts was coordinated by a konohiki, or land agent of the ruling class (McAllister 1933). With the significant disruption of Hawaiian society, this area was probably one of the first ponds to fall into disuse. An 1851 map of nearby Ka'elepulu pond still designated Ka'elepulu as a loko, that is a fishpond with an open connection to the sea. Kawainui was only sketchily indicated and was not designated as a fishpond.

Taro and dryland (kula) farming continued above and below the marsh as indicated by an 1890 map. In contrast with the present map, there was still a substantial body of open water in the marsh. Summers (1964) reported that at one time this lake was 180 ha in area. This figure corresponds with the area now covered by peat, 180 ha (Dames and Moore, Inc. 1961).

The fourth management phase involves use of the marsh as a source for irrigation water and active management of its waters as a resource.

Until this time the area was probably brackish. Some time between 1860 and 1876 rice farming began on the windward side of O'ahu (Coulter and Chun 1937, Pratt 1965). Weirs were constructed to keep out the intrusion of seawater. The marsh became a freshwater environment. The marsh water was used to irrigate the rice fields. They are seen in Kawainui Marsh on a photograph taken in 1926 and published in Honolulu Magazine (1975). According to Pratt (1965) former taro patches, as well as previously unused areas were converted to rice.

By 1934 only 1,000 kg of rice were produced in the entire territory of Hawai'i, as California entered the market as a major rice producer. According to Coulter and Chun (1937) rice production in Hawai'i had been declining since about 1900, so that between 1900 and 1934 rice farming must have ceased to be important in Kawainui.

In the meantime, other agricultural demands had arisen which required that Kawainui Marsh be kept a freshwater environment.

In 1878 Waimanalo Sugar Plantation was founded (Anonymous 1882). The plantation drew irrigation water from Kawainui Marsh. From the time this plantation was founded until 1950 the marsh was dammed in the winter to conserve water (H. Wong, personal communication).

By 1926 the ranch had planted *Brachiaria mutica* in the marsh as pasturage for cattle (Henke 1929). This plant is not a halophyte and needs a freshwater environment (P. Rotar, personal communication).

By the time that Kaneohe Ranch ceased selling irrigation water from Kawainui to Waimanalo Sugar, a diversion ditch to Waimanalo had been constructed above the marsh. This ditch is still in operation and draws about 7,500 m^3 per day of water which would be tributary to the marsh.

In 1952 Kawainui Canal was constructed; a weir was installed to maintain the freshness of the marsh, and the marsh was cut-off from Kawainui Stream, hence Ka'elepulu Stream. Drainage was then to the north end of Kailua Bay, as it is now, rather than to the south end, as it had been before.

From 1955 through 1965 Kaneohe Ranch maintained a pump at the head of the new canal, downdrawing on the marsh by 37,700 m^3 per day. This was done specifically to increase the amount of *Brachiaria mutica* pasturage for ranch cattle (H. Wong, personal communication). This was the last major event of active water management in the marsh.

The fifth phase of development began in 1966 with the enlargement of Kawainui Canal and the construction of a 3-m high levee between the marsh on one side and Kawainui Stream and Kailua town on the other. This levee further isolated the marsh from Kawainui Stream. Since then, the lack of ground water interchange between the marsh and Kailua town has been demonstrated (Swain and Huxel 1971).

Major events in the development of the marsh are outlined in Table 2.

Table 2. Manipulations of water levels in Kawainui Marsh and the probable effects. Some of the early dates are approximate.

Date	Event	Probable Effects
1851	Fish culture, taro	Vegetation kept cleared from pond; drainage cared for; channel to Kailua Bay kept open and marsh brackish.
1860-1876	Rice and taro culture	Weirs installed and diversion ditches for irrigation of rice; water fresh.
1878	Impoundment of pond; irrigation source for Waimanalo Plantation	Rise in water levels to +1 msl; salinity of water 3°/₀₀.
1926-1929	*Brachiaria mutica* planted for pasturage	Grass community established.
1900-1934	Rice culture discontinued	Diversion ditches to rice fields abandoned; weirs still in place.
1952	Kawainui Canal cut, weir installed	Stream flow diverted from Ka'elepulu; freshness of water maintained.
1955-1965	Downdraw of 37,700 m^3 per day; weirs maintained	Water level kept at -1.5 m msl; grass spreads, bulrush community retreats.
1966	Kawainui Canal enlarged; levee built; weirs discontinued	Water level to present average of +1 m msl; canal and marsh cut-off from Kawainui Stream; only minor incursion of seawater at head of canal.

Aerial photographs and one map were used to estimate the aerial extent of the two vegetation types through time. The areas (Figs. 2-7) as well as the date of the photographs and map, and the pertinent water management events are shown in Table 3.

Areas of open water (Figs. 2-7) were examined with respect to time. There was no apparent relationship between water management and amount of open water. Given the ability of the vegetation to cover areas of water, no relationship was expected. The results are given in Table 4.

Table 3. Changes in the areas of the bulrush and grass communities with respect to time and water manipulations. Areas are in hectares.

Map or Photo Date	Grass	Bulrush	Event
1974	120	160	none
1971	120	160	none
1969	150	130	present canal & levee in place
1962	180	100	drawdowns
1955	120	160	none
1926	?	270	impoundment
1890	?	220	impoundment

Table 4. Areas of open water. Areas are in hectares.

Map or Air Photo Date	Season	Area	Historical Event
1974	summer	5	none
1970	?	5	none
1969	fall	16	none
1962	fall	1	drawdown
1959	?	4	drawdown
1955	winter	8	impoundment
1952	?	5	impoundment
1949	fall	3	impoundment
1928	?	7	impoundment
1926	?	7	impoundment
1908-1913	?	16	impoundment
1890	summer	26	impoundment

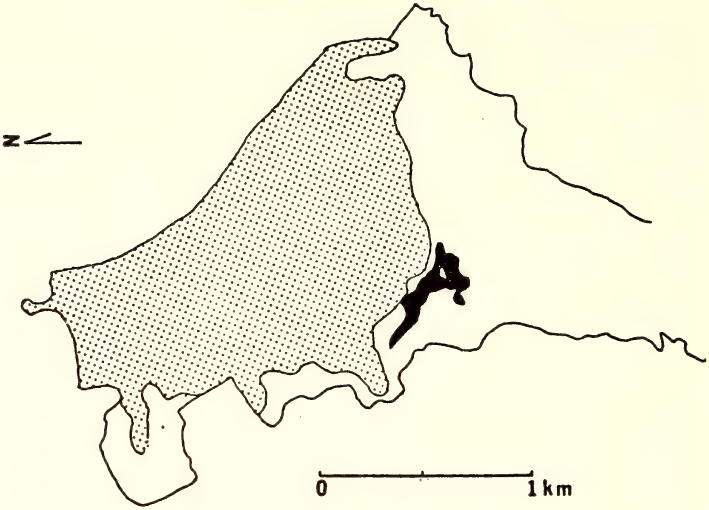


Figure 3. Drawn from an aerial photograph. 1971. U.S. Navy. Naval Undersea Center, Hawaii Laboratory, Kailua, Hawaii.

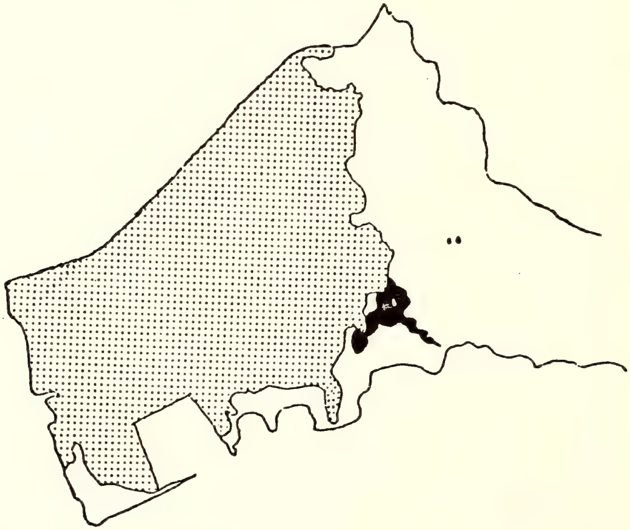


Figure 2. Drawn from an aerial photograph. 1974. NASA U-2 photo. State of Hawaii, Department of Planning and Economic Development, Honolulu.

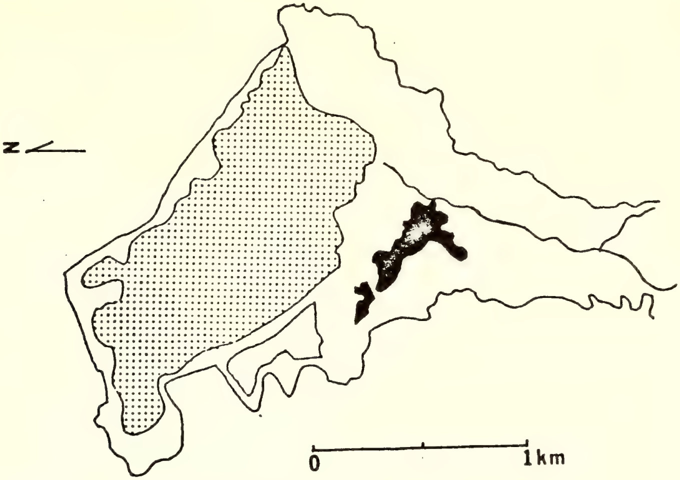


Figure 5. Drawn from an aerial photograph. 1962. R.M.Towill Corp. Honolulu.

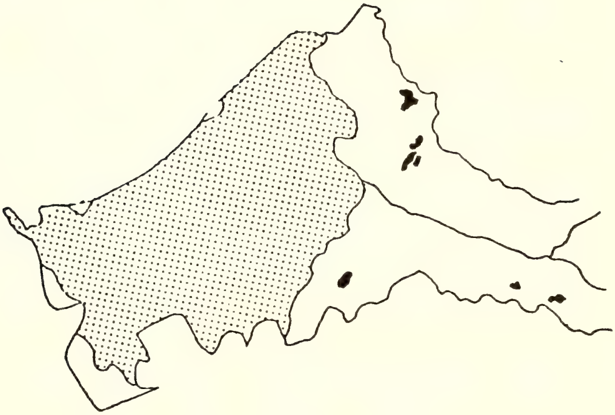


Figure 4. Drawn from an aerial photograph. 1969. R.M.Towill Corp. Honolulu.

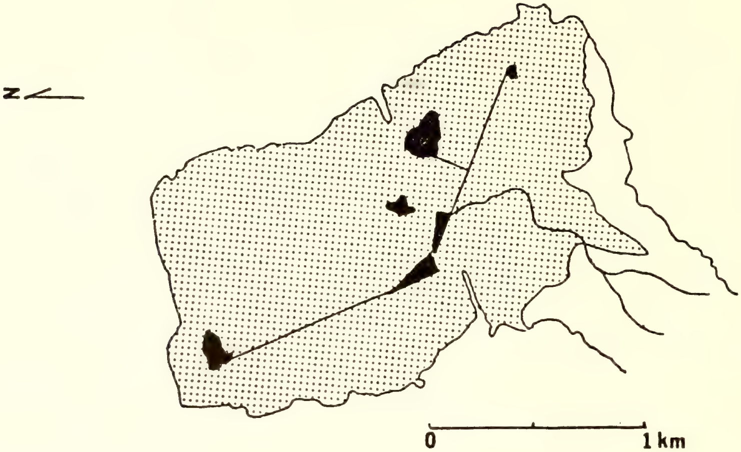


Figure 7. Drawn from an aerial photograph. 1926. U.S. Army Department U.S.G.S. file copy, Honolulu.

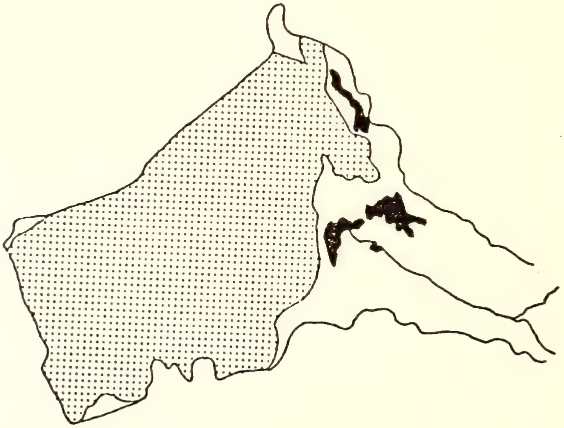


Figure 6. Drawn from an aerial photograph. 1955. R.M.Towill Corp. Honolulu.

Discussion

Present Vegetation

1. Grass Community

The *Brachiaria* community is one of extremely low diversity. A total of only 6 species were found in that community. It has been my observation that where *Brachiaria* occurs, few other species are generally present. This may be attributable to its extremely high production rates. Bown *et al.* (1966) reported productivities of this grass of up to 123 mt per ha per year, wet weight in Hawai'i. Preliminary production estimates for this grass in Kawainui Marsh support this high production estimate.

Brachiaria forms very dense mats of living material. In this study, mats of this grass easily supported the weight of a person weighing 70 kg. Bown *et al.* (1966) reported that mats of *Brachiaria* could completely cover small ponds and would become dense enough to support the weight of a grown cow. This phenomenon was also observed in Kawainui.

Ross (1971) used white Chinese geese as a control measure for this grass. These fowl were able to completely clear a small pond on O'ahu in two year's time. It may be that the amount of open water remaining in the marsh is attributable to the feeding habits of the wild birds there.

Although *Brachiaria* is an active mat-former, no peat was found in the grass community. This community occurs on fine, alluvial clays which are damp in all seasons, but flooded only periodically. The living plants were underlain by a thin layer of litter and soil.

2. Bulrush Community

This community does form mats of peat (preserved dead organic material). It is basically an aquatic community.

While still a community of low diversity, with only 18 plant species found, this community has a higher diversity than the grass community. A preliminary estimate of productivity suggests that is is also a more productive community than the grass community. While this estimate is preliminary, it is the first estimate made for a marsh species in the tropics which also occurs in temperate-climate regions. Therefore, is is probably worthwhile to note that it is comparable to estimates made for *Scirpus* under temperate conditions, if the measured growth rate is extrapolated to 12 months.

The bulrush community, although basically of aquatic origin, supports plant species which are not typically wetland plants, e.g., paperbark trees, wild sugarcane. The floating mats of vegetation and peat produced by the emergent aquatic plants, i.e., taro patch fern, sawgrass, and bulrush, provide a pseudo-terrestrial environment for non-aquatic plants. This situation has been reported for water hyacinth mats in Louisiana by Penfound and Earle (1948) and for the Everglades by Loveless (1959) and others.

Perturbations and Responses

1. Fire

The presence of paperbark trees in Kawainui Marsh may suggest a tendency for the development of a woody community if further burning is allowed. Paperbark is known to have a positive germination response to fire (Gore 1976). The notable lack of success of the seedlings which sprouted after the 1975 fire, however, tends to indicate that this process, if occurring is slow. Paperbark was introduced to Hawai'i in 1929 (St. John 1973). In almost 50 years only about 30 small (less than 3-m tall) trees have succeeded in becoming established in the marsh.

Sawgrass is known to have a positive growth response to fire (Loveless 1959). Continued burning of the marsh could increase the distribution of this species. It tends to occur as pure stands in the bulrush community, but is not distinguishable on aerial photographs. Therefore, before and after comparisons of its distribution with respect to the 1975 fire were not possible.

If this plant were to become dominant in the ponding basin, the nutrient assimilation capacity of the marsh would probably drop. Steward and Ornes (1974) demonstrated that in Florida a different species of sawgrass (*Cladium jamaicense*) showed little or no response to eutrophication, exhibited no luxury uptake, and that nutrients tended to accumulate in the sediments.

2. Salinity

At least one source on Hawaiian fishpond management (McAllister 1933) and examination of former drainage patterns for Kawainui Marsh suggest that the area has been changed from a brackish water environment to a fresh one. Historical records (Shaw 1927 and Harloe 1948) indicate that considerable effort has been expended in the past to maintain freshness of the water. A fresh water environment is a prerequisite for many of the exotic plant species which have become established in the marsh, e.g., *Brachiaria*, wild sugarcane, and others. However, the native bulrush and sawgrass are tolerant of a wide range of salinities and have maintained their dominance despite the change.

3. Water Levels

Past water impoundments and drawdowns have substantially altered the size of the two communities now present in the marsh. Table 3 shows that without any active management of the marsh, the bulrush community tends to occupy about 160 ha. Impoundments resulted in a high of 220 ha for this community; the drawdown of 1955-1965 reduced the bulrush community to a total of 100 ha. However, with the return of higher levels, the bulrush community re-established itself in an area of about 160 ha.

4. Plant Introductions

Species composition of the marsh has been, to a large extent, influenced by the introduction of exotic plants. Agricultural species replaced native plants in the drier portions of the marsh from pre-European times. These plants were then deliberately replaced (Henke 1929) by another introduction, *Brachiaria mutica,* which now occupies about half of the marsh.

Introduced species occur throughout the bulrush community. *Scirpus californicus* may be an introduced species. However, *S. validus* is generally thought to be native (St. John 1973); however, Fosberg (personal communication) considers these two plants to be synonymous in Hawai'i. I accept Fosberg's judgment on this and consider the dominant plant in the ponding basin to be a native which provides a pseudo-terrestrial environment for other species, many of which are exotics.

Cladium leptostachyum (sawgrass) is native to Hawai'i (St. John 1973). Two other native plants were found in the marsh: the taro patch fern, *Cyclosorus interruptus,* and one specimen of *Hibiscus youngianus.*

The earliest photograph of the area (1926) shows the marsh looking very much as it does today with only 7 ha of open water (now there are 5 ha of open water). However, as late as 1890 there was a large body of water (26 ha) in the marsh. Thus, in less than 36 years, emergent aquatics almost completely covered the open water. Elliott and Hall (1977) described such a closure of open water by emergent aquatics in Ka'au Crater, O'ahu. They described the vegetation as consisting of *Scirpus validus, Cladium leptostachyum,* and *Commelina diffusa,* an assemblage of plants similar to that in the bulrush community of Kawainui Marsh.

5. Nutrients

Since 1926, there has been no change in the general character of the vegetation in the marsh, none which is perceptible in aerial photographs. Hence, perturbations to the system since 1926 would seem to have caused no major or lasting effects on the marsh as a whole. Since that time four secondarily-treated sewage effluents have been introduced into the marsh. They now add about 18 mt (1.3×10^6 moles) of nitrogen and 7 mt (2.3×10^5 moles) of phosphorus annually (Department of Public Works, Honolulu). A sanitary landfill was constructed upstream from the marsh. Stormwater runoff should bring added nutrients into the marsh from the landfill. In addition, many acres of the surrounding watershed have been developed as housing subdivisions. Chun and Dugan (1977) reported that such development increases the nitrogen loading of runoff water. Yet the only perturbations which have had an obvious effect since 1926 are manipulations of water levels and exotic plant introductions.

That this should be so is explained by the tremendous capacity of freshwater wetlands to assimilate nutrients. Woodwell (1977), de Jong (1976) and others advocate use of such wetlands for final treatment of wastewater and contend that this is a reasonable and economical use of such areas. Woodwell (1977) calculated that approximately 20 ha of wetland could process the domestic sewage for 10,000 people. Preliminary water quality data on Kawainui Marsh suggest that the marsh adequately strips the water column of nutrients. Valiela *et al.* (1977) noted that in their studies of wetland eutrophication they have yet to find an upper limit of nutrient loading for such systems.

The same authors (Valiela *et al.* 1977) remarked on the resilience of wetland communities to eutrophication. They observed, in general, that there were productivity and standing crop changes relative to the amount of nutrient loading, but that the integrity of species composition was unaffected. This is in contrast to the effects of eutrophication observed for woodlands (Woodwell 1977), in which species composition was drastically changed with increased nutrient loading.

The observations in Kawainui Marsh of community resilience to eutrophication demonstrate in particular, for a tropical native community (the bulrush), an effect noted in general for wetlands by other workers in other areas.

6. Flood Control

As a ponding basin, the marsh serves the surrounding suburban areas as an aid in flood control. Kailua town has been subject historically to flooding (Swain and Huxel 1971, Harloe 1948). I personally experienced one such flood while living in Coconut Grove in 1967. During the rainy season the water level in Kawainui Marsh may normally rise as much as 1 m (U.S.G.S. water level records) thereby retarding the instantaneous flow of at least 180,000 m^3 of water. This water is then subsequently released, over a period of time, to Kailua Bay via Kawainui Canal. In addition to sparing Kailua the effects of flooding, the slow release of fresh water moderates its effects on the marine environment of Kailua Bay, a popular and heavily-used recreational area.

Conclusions

The creation of a fresh water environment in Kawainui Marsh laid the groundwork for the establishment of exotic plant species. Exotic plants have, in turn, determined the present character of the marsh. The *Brachiaria* community is composed of an exotic which tends to exclude other plant species. The bulrush community provides a pseudo-terrestrial environment for the establishment of exotics. This community is dominated by native plants and is a specific instance of native vegetation maintaining its integrity despite alteration and stress.

Left as it is, the marsh system is probably stable. The only perturbations which have had an observable effect on the marsh since 1926 have been water level manipulations, which have altered the relative areas of the two plant communities, but not their character, and exotic plant introductions. Fire could have the long-term effect of increasing a woody component of the bulrush community, however, no evidence was found to support such a hypothesis.

The marsh today serves at least three functions. It aids in flood control, serves as a final treatment facility for sewage effluents, and provides open greenspace in an area which is being rapidly urbanized.

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Appendix 1. Plant species list. Plants of Kawainui Marsh and peripheral areas bounded by Kailua and Quarry Roads. Common names are given if known. An asterisk denotes that the plant was found within the study area of the marsh, below the 3-m topographic contour. Voucher specimens are in the herbarium of the Department of Botany, University of Hawaii. Nomenclature is after St. John (1973) except where alternate names have been supplied by Dr. F. Raymond Fosberg, Senior Botanist, National Museum of Natural History, Smithsonian Institution, Washington, D.C. Some plants listed here do not appear in St. John. For these names other sources were consulted (e.g., Neal 1965, Degener and Degener 1957). Under "status" I indicates an introduced plant, N a native one.

FLOWERING PLANTS Scientific Name	Status	Common Name
Acanthaceae		
Asystasia gangetica (L.) T. Anders	I	asystasia
Alismataceae		
**Sagittaria sagittaefolia* L.	I	arrowhead
Amaranthaceae		
**Amaranthus spinosus* L.	I	spiney amaranth
**Alternanthera sessilis* (L.) R. Br.	I	none
Anacardiaceae		
**Schinus terebinthifolius*	I	Christmasberry

Appendix 1 (continued).

FLOWERING PLANTS

Scientific Name	Status	Common Name
Apocynaceae		
Allamanda hendersonii Bull.	I	cup-of-gold
Araceae		
Epipremnum pinnatum (L.) Engler	I	taro vine
Philodendron lacerum (Jacq.) Schott	I	none
Philodendron scandens Koch & Sello	I	none
Pistia stratiotes L.	I	water lettuce
Syngonium podophyllus (L.) Schott	I	taro
Araliaceae		
Brassaia actinophylla Endl.	I	octopus tree
Balsaminaceae		
Impatiens sultanii Hook	I	impatiens
Bignoniaceae		
Spathodea campanulata Beauv.	I	African tulip
Casuarinaceae		
Casuarina equisetifolia L.	I	ironwood
Caricaceae		
Carica papaya L.	I	papaya
Chenopodiaceae		
Chenopodium murale L.	I	goosefoot
Commelinaceae		
Commelina diffusa Burm. f.	I	day flower
Zebrina pendula	I	wandering Jew
Compositae		
Ageratum conyzoides L.	I	ageratum
Bidens pilosa L.	I	Spanish needle
Bidens pilosa var. *minor* (Bl.) Sherf.	I	none
Conyza bonariensis (L.) Cronq.	I	hairy horseweed
Eclipta alba (L.) Hassk	I	false daisy
Elephantopus mollis HBK	I	elephant's foot
Emilia fosbergii Nicolson (*E. javanica* sensu St. John)	I	flora's paintbrush
Emilia sonchifolia (L.) DC	I	flora'a paintbrush
Pluchea x *fosbergii* Coop. & Gal.	I	pluchea
Pluchea indica (L.) Less.	I	Indian pluchea

Appendix 1 (continued).

FLOWERING PLANTS Scientific Name	Status	Common Name
Compositae (continued)		
**Pluchea symphytifolia* (Mill.) Gillis (*P. odorata* sensu St. John)	I	shrubby fleabane
Siegesbeckia orientalis L.	I	siegesbeckia
**Sonchus oleraceus* L.	I	sow thistle
Synedrella nodiflora (L.) Gaertn.	I	nodeweed
**Verbesina encelioides* (Cav.) Benth.	I	golden crownbeard
Vernonia cinearea (L.) Less.	I	ironweed
Wedelia trilobata L.	I	wedelia
Convolvulaceae		
Ipomoea alba L.	I	moon flower
**Ipomoea indica* (Burm.) Merr. (*I. congesta* sensu St. John)	I	morning glory
**Ipomoea aquatica* Forsk.	I	swamp cabbage
**Ipomoea obscura* (L.) Ker-Gawler	I	none
Merremia tuberosa (L.) Rendle	I	wood rose
Cucurbitaceae		
Momordica charantia L.	I	bitter melon
Cyperaceae		
**Cladium leptostachyum* Nees & Meyen	N	sawgrass
**Cyperus alternifolius* L.	I	umbrella plant
Cyperus brevifolius (Rottb.) Hassk.	I	kyllingia
Cyperus diformis L.	I	none
**Cyperus kyllingia*	I	kyllingia
Eleocharis acicularis (L.) R. & S.	I	pipi wai
Eleocharis obtusa (Willd.) Schult.	N	none
Scirpus californicus (C.A. Mey.) Stendel	N	bulrush
Euphorbiaceae		
Euphorbia cyathophora Murr. (*E. glomerifera* sensu St. John)	I	none
Euphorbia hirta L.	I	garden spurge
Ricinis communis L.	I	castor
Gramineae		
**Brachiaria mutica* (Forsk.) Stapf	I	California grass
**Cenchrus echinatus* L.	I	sand bur
Chloris inflata Link	I	swollen finger grass
Cynodon dactylon (L.) Pers.	I	Bermuda grass
Eleusine indica (L.) Gaertn.	I	wire grass

Appendix 1 (continued).

FLOWERING PLANTS Scientific Name	Status	Common Name
Gramineae (continued)		
Panicum maximum Jacq.	I	Guinea grass
Paspalum conjugatum Berg.	I	Hilo grass
Paspalum dilatatum Poir.	I	dallis grass
**Paspalum distichum* L.	I	knott grass
**Pennisetum purpureum* Schumach.	I	napier grass
Pennisetum clandestinum Hochst.	I	kikuyu grass
Saccharum officinarum L.	I	sugarcane
Saccharum sponteneum L.	I	wild sugarcane
Setaria palmaefolia (Koen.) Stapf	I	palm grass
Sorghum halepense (L.) Pers.	I	johnson grass
Sporobolus virginicus (L.) Kunth	N	beach dropseed
Trichachne insularis (L.) Nees	I	sour grass
Leguminosae		
Canavalia cathartica Thouars	N	mauna loa
Cassia bicapsularis L.	I	none
**Cassia surattensis* Burm. f.	I	kolomona
**Crotalaria incana* L.	I	fuzzy rattlepod
**Crotalaria pallida* Wit. (*C. mucronata* sensu St. John)	I	rattlebox
**Desmanthus virgatus* (L.) Willd.	I	virgate mimosa
**Desmodium canum* (Gmel.) Schinz & Tellung	I	Spanish clover
**Indigofera suffruticosa* Mill.	I	indigo
**Leucaena leucocephala* (Lam.) de Wit.	I	haole koa
**Mimosa pudica* L.	I	sleeping grass
Mucuna gigantea (Willd.) DC	N	sea bean
**Phaseolus lathyroides* L.	I	wild bean
Samanea saman (Jacq.) Merr.	I	monkeypod
Lemnaceae		
**Lemna minor* L.	I	duckweed
Spirodela polyrrhiza (L.) Schleid	I	greater duckweed
**Spirodela punctata* (G.F.W. Meyer) Thompson	?	duckweed
**Wolffia columbiana* Karst.	?	water meal
Liliaceae		
Cordyline fruticosa (L.) Chev. (*C. terminalis* sensu St. John)	I	ti
Loganiaceae		
Buddleja asiatica Lour.	I	dogtail

Appendix 1 (continued).

FLOWERING PLANTS		
Scientific Name	Status	Common Name
**Abutilon grandifolium* (Willd.) Sweet	I	hair abutilon
**Hibiscus tiliaceus* L.	N	hau
**Hibiscus youngianus* Gaud.	N	native pink hibiscus
**Sida acuta* var. *carpinifolia* Burm. f.	I	ilima
Sida rhombifolia L.	I	Cuba jute
Sida spinosa L.	I	prickly sida
Moraceae		
Ficus elastica Roxb. ex Hornum	I	rubber plant
**Ficus microcarpa* L.	I	Chinese banyan
Myrtaceae		
Eugenia cumini (L.) Druce	I	Java plum
**Melaleuca leucadendra* (Stickm.) L.	I	paperbark
Psidium guajava L.	I	guava
Musaceae		
Heliconia caribaea Lam.	I	heliconia
Musa paradisiaca L.	I	banana
Strelitzia sp.	I	bird-of-paradise
Nyctaginaceae		
Mirabilis jalapa L.	I	four o'clock
Nymphaceae		
**Nymphaea lotus* L.	I	Egyptian lotus
Onagraceae		
**Ludwigia octovalvis* (Jacq.) Raven	I	primrose willow
Ludwigia palustris (L.) Ell.	I	water purslane
Orchidaceae		
**Spathoglottis plicata* Bl.	I	Maylayan ground orchid
Oxalidaceae		
Oxalis corniculata L.	I	yellow wood sorrel
Oxalis corymbosa DC (*O. martiana* sensu St. John)	I	pink wood sorrel
Passifloraceae		
Passiflora edulis Sims	I	lilikoi
**Passiflora foetida* L.	I	scarlet-fruited passion flower
Passiflora subpeltata Ortega	I	white passion flower

Appendix 1 (continued).

FLOWERING PLANTS Scientific Name	Status	Common Name
Plantaginaceae		
**Plantago major* L.	I	common plantain
Plumbaginaceae		
**Anagalis arvensis* L.	I	scarlet pimpernel
Pontederiaceae		
**Eichhornia crassipes* (Mart.) Solms.	I	water hyacinth
Monochoria vaginalis (Burm. f.) Kunth	I	cordate monochoria
Portulacaceae		
**Portulaca oleracea* L.	I	stink vine
Scrophulariaceae		
Bacopa monnieri (L.) Wettst.	N	water hyssop
Solanaceae		
Capsicum frutescens L.	I	red pepper
Lycopersicon esculentum Mil.	I	tomato
Solanum nigrum L.	?	black nightshade
Solanum seaforthianum Andr.	I	none
**Solanum sodomeum* L.	I	apple of sodom
Tiliaceae		
Triumfetta rhomboidea Jacq.	I	Sacramento bur
Typhaceae		
Typha latifolia L. (*T. angustata* sensu St. John)	I	cattail
Verbenaceae		
Clerodendrum philippinum Schau.	I	fragrant clerodendrum
**Stachytarpheta urticaefolia* (Salisb.) Sims	I	false vervain
Zingerberaceae		
Alpinia speciosa (Wendl.) K. Schum.	I	shell ginger
FERNS		
Parkeriaceae		
Ceratopteris siliquosa (L.) Copel	?	swamp fern

Appendix 1 (continued).

FERNS

Scientific Name	Status	Common Name
Polypodiaceae		
Pityogramma calomelanos (L.) Link	I	gold fern
Microsorium scolpendra Burm. f.	I	none
Nephrolepis hirsutula (Forst.) Presl.	?	sword fern
Thelypteridaceae		
**Cyclosorus interruptus* (Willd.) H. Ito	I	taro patch fern

HAWAIIAN FIBER PLANTS

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In the past, a fair amount of attention has been directed to Hawaiian food and medicinal plants. Today, on the other hand, there is a renewed interest in the Hawaiian fiber plants. The following list contains the names of plants reported to have been used for their fibers. Not all these have been tested to see if they produce fibers in usable quantities, but where possible, methods of fiber retrieval have been included. Likewise, the uses of the fibers are listed, but it must be kept in mind that many authors who have written on this subject never actually saw the processes carried out nor have artifacts made of these fibers been examined to verify the plant source. Currently several ongoing investigations are being conducted to establish the presence of usable fibers in some of these plants.

A fiber plant is defined in conventional terms as any plant that produces stem, leaf, or seed structures or tissues that can be spun, i.e. twisted together or plaited, or beaten into barkcloth. In this paper, the definition is broadened to include any taxon that produces useful fibers or hairs; processed or not. As an example, *Canavalia* was stripped of its leaves and braided, and the hairs from *Cibotium* were used for bandages and embalming without processing.

Scientific Name	Common Name	Hawaiian Name
Artocarpus altilis (Parkins. ex Z)	Breadfruit	Ulu

Uses: Very young branch tips were used for tapa making.

Preparation method: The material was retted (1,4,5,6,7,9,12,13,14).

Asplenium adiantum-nigrum L.	Maiden hair fern	Iwa'iwa

Uses: Stems were woven into fish traps and baskets or incorporated into small mats and objects made of lauhala for decoration.

Preparation method: Leaves and branches were removed from stems (3,9,12, 13).

Asplenium nidus L.	Birds-nest fern	Ekaha

Uses: The shiny outer layer of the mid-rib was incorporated into small mats and objects made of lauhala for decoration.

Preparation method: The shiny outer layer of the mid-rib was peeled from fresh fronds (9,12,11,13).

Bambusa vulgaris Schard. ex Wendl.	Bamboo	Ohe

Uses: House building, fishing poles, fans, mats, bellows, knives, straight edges, nose flutes, percussion instruments and canoe outriggers. In tapa making, single and multiple pointed pens and carved stamps were made of bamboo. Needles, sled runners and steaming tubes and pipes were also fashioned from this material.

Preparation method: In house building the leaves were sometimes used for thatch as they came from the plant. It is known that bamboo strips were used for tying, but the preparation method is not known (5,4, 6,9,11,12,13).

Boehmeria grandis (H. & A.) Heller	Ramie	Mamaki

Uses: Inner bark was used for making coarse tapa.

Preparation method: The material was retted (4,6,9,12,13,14).

Broussonetia papyrifera (L.) Vent.	Paper Mullberry	Wauke

Uses: Inner bark was used for tapa, cordage, sandals and bed clothing.

Scientific Name Common Name Hawaiian Name

Broussonetia papyrifera (con't.)

Preparation method: Inner bark was retted (2,1,5,3,4,6,7,8,9,10,12,13, 14).

Canavalia galeata (Gaud.) Vogel Awikiwiki

Uses: Temporary baskets and fish traps.

Preparation method: Leaves were stripped from fresh vines that were then braided or plaited into the desired temporary product (5,9,12,13).

Cardiospermum halicacabum L. Balloon Vine Inalua or Poniu

Uses: Small fish basket traps. Another Hawaiian name for this plant is Haleakai'a which literally translated is "house of the fish."

Preparation method: Not known (5,9,12,13).

Cladium leptostachyum Nees & Meyen Sawgrass Uki

Uses: Leaves used for tying.

Preparation method: No special preparation (9,12,13).

Cibotium splendens (Gaud.) Krajina ex Skottsb. Tree Fern Hapu'u

Uses: The "pulu" from the base of the fronds was used for dressing wounds and for embalming the dead.

Preparation method: None (2,5,6,9,11,12,13).

Cocculus ferrandianus Gaud. Moonseed Huehue

Uses: The vines were used for twine and for funnel-mouthed fish traps.

Preparation method: The leaves were removed from the vines and the stems were used fresh (7,9,12,13).

Scientific Name	Common Name	Hawaiian Name
Cocos nucifera L.	Coconut	Niu

Uses: Husk fibers were used to make rope and twine. Leaves were plaited for thatch, baskets, and fans. Mid-ribs were used to string "kukui" nuts for lights. The fiber found at the base of the leaves was used for sandals, strainers and loin cloths.

Preparation method: Husks were soaked in sea water until fibers could be readily separated. Mid-ribs were removed from leaflets by removal of the blade. No known method of preparation of the leaf base fiber (1,2,3,5,6,7,8,9,12,13).

Cordyline terminalis var. *ti*	Ti	Ti

Uses: Leaves were used for house thatch, rain capes, food wrappers and plates. Dry leaves were used on drag lines to drive fish into shallow water during the "hukilau."

Preparation method: Where flexible leaves were needed the mid-rib was removed (3,5,6,7,9,11).

Cyperus laevigatus L.	Sedge	Ehu'awa

Uses: Stems were woven into fine mats (Ni'ihau mats). The product is said to have been fine enough to be worn for clothing such as loin cloths, capes, and pa'u. The mats were also used for bed and floor coverings.

Preparation method: Only stems were used. No special preparation (3,5,7,9,12).

Cyperus javanicus Houtt.	Sedge	Ahu'awa or Ehu'awa

Uses: Fibers from stem were used for strainers for "awa" or coconut or spun or twisted into cordage and rope (3,5,7,9,12).

Preparation method: Stems were crushed and the fibers stripped.

Dianella sandwicensis H. & A.		Uki'uki

Uses: Leaves were used for inside thatching of house walls and for braid in house building.

Preparation method: Leaves were tied in bundles either fresh or dried (3,5,6,9,12).

Scientific Name Common Name Hawaiian Name

Elaeocarpus bifidus H. & A. Kalia

Uses: Fibers from the inside bark of Kalia were used for string and cordage.

Preparation method: Fibers were obtained by retting (9,12,13).

Freycinetia arborea Gaud. Ie'ie

Uses: Aerial roots were used to make twinning baskets. Split roots were made into calabash covers, fishbaskets, shrimp and fish traps and for bases of idols and helmets.

Preparation method: Where whole roots were used, no special preparation was needed. Split roots were obtained by passing whole roots over a sharp edge to split them (3,5,6,9).

Heteropogon contortus (L.) Pili

Uses: This is one of the grasses used to thatch grass houses. It was preferred material because of its pleasant odor, neat appearance and light brown color.

Preparation method: Dried material was tied into bundles and the bundles were tied to the house frame (3,5,7,8,9).

Hibiscus tiliaceus L. Hau

Uses: The inner bark was used to make rope, net bags, koloa, for snap lines and for sewing tapa, basket tops and sandals.

Preparation method: Usable material was obtained by retting (2,3,4,5,6,7,9,11,14).

Ipomoea brasiliensis (L.) Sweet Beach Morning Glory Pohuehue

Uses: Vines were used to drive fish into traps or leaves were stripped from stems which could then be used to make temporary ropes or lines.

Preparation methods: No special preparation (5,9,12).

Scientific Name	Common Name	Hawaiian Name
Ipomoea cairica var. *lineariloba* (Hbs.) Deg. & van Ooststr.	Morning Glory	Koali

Uses: Stems were used for cordage to tie house parts together.

Preparation method: Unknown (7,9,12).

Machaerina angustifolia (Gaud.)	Sedge	Uki

Uses: Leaves used for tying and for lashing thatch to houses.

Preparation method: No special preparation (9,12,13).

Machaerina mariscoides (Gaud.) Kern	Sedge	Uki

Uses: Leaves used for tying and for lashing thatch to houses.

Preparation method: No preparation known (9,12,13).

Musa spp. L.	Banana	Mai'a

Uses: The black skin of the trunk was used to decorate items plaited of lauhala, the trunk fiber was used for house building, the leaves for making sandals and in tapa making.

Preparation method: Unknown (1,2,3,5,7).

Neraudia melastomaefolia Gaud.		'Oloa or ma'aloa

Uses: The inner bark was used for tapa making.

Preparation method: Usable fibers were obtained by retting (4,5,6,9,10).

Osteomeles anthyllidifolia Lindl.		Ulei

Uses: Flexible branches were used in making fish traps and nets.

Preparation method: Unknown (5,6,7,9).

Pandanus spp. Stickm.	Screw pine	Hala

Uses: Used to make baskets, fans, sandals, pillows, sails, house thatch and paint brushes.

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Contents

VOLUME 17 NUMBER 3/5 MAY/DECEMBER 1978

HALEAKALA - A TROPICAL ALPINE AND SUBALPINE AREA
by Louis D. Whiteaker.............................36

ST. JOHN'S HAWAIIAN PLANT NOVELTIES SINCE 1972
by Harold St. John................................56

ADAPTIVE RADIATION IN THE SILVERSWORD ALLIANCE - AN OVERVIEW
by Gerald D. Carr.................................64

RECENT PACIFIC PUBLICATIONS - 4
by Charles H. Lamoureux and William J. Hoe......69

RECENTLY COMPLETED THESES IN BOTANICAL SCIENCES AT UNIVERSITY OF HAWAII.........................81

SOCIETY BUSINESS...........53,54,55,63,77,78,79,80

*

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HALEAKALA - A TROPICAL ALPINE AND SUBALPINE AREA

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Tropical alpine and subalpine areas in the world are subject to a number of common environmental factors in spite of their biogeographic isolation. Higher radiation intensity especially at the short-wavelength end of the electromagnetic spectrum, for example, is a characteristic common to all these high altitude areas. This higher intensity is related to their topographic positions which are above the general screen of oxygen, dust, water vapor, clouds, and carbon dioxide. These materials are retained in the lower atmosphere by the inversion layer where they absorb or reflect solar radiation. The evolution of flat, silver or grey hairs on the leaves of several alpine species is seen as an adaptation to withstand this intense radiation by increasing the albedo of the plant (Carlquist 1970).

In alpine and subalpine areas, the decrease in temperature with increasing elevation is described as an important environmental factor. This relationship between temperature and elevation contributes to a certain altitudinal zonation on different tropical high mountains (Hedberg 1951). Also, although tropical areas are known for their very limited seasonal variation in temperature, diurnal variation in temperature is an important ecological factor. A remarkable diurnal fluctuation of temperature occurs in high mountains where, characteristically, the heating of the surface is intense during the day and cooling is rapid during the night. This has been termed by Hedberg (1975) "winter every night and summer every day." Coe (1967) suggested that such a temperature regime must be an important selective factor in the evolution of the tropical mountain flora.

A related factor which has been described as important in almost all tropical, alpine areas is the occurrence of night frost. The frost and thaw cycle results in the sorting of soil particles by size. This, in turn, produces stone rings or stone strips on slopes. Because of the steady decrease of temperature with elevation and the diurnal temperature fluctuation as noted above, frost may occur almost every night of the year above a certain elevation. On Mauna Loa in Hawai'i, the diurnal frost boundary was observed to occur at approximately 2600 m (8600 ft.). and to coincide with the boundary of a vegetation community-type (Mueller-Dombois 1967). In South America, the boundary between Puna, a seasonally dry area of the southern high Andes, and alpine desert is defined as the elevation where frost occurs each night (Troll 1966). This elevation is a little below 4000 m (13,000 ft.) in these mountains (Walter 1971). Natural selection favors those plants that can adapt their growth forms to tolerate daily freezing. These adaptations are predominantly expressed as megaphytic (large bodied) and rosette life-forms (Troll 1958; Coe 1967), but also other life-forms, for example, cushion plants.

Altitudinal Zonation

The use of the word alpine presents a problem in the altitudinal zonation of tropical mountains. In temperate regions, the lower limit of the alpine zone is clearly defined by a well-marked tree line. In tropical high mountain areas, however, such a tree line is often absent and is replaced by a gradual transition from montane forest to a park-like vegetation which gradually merges into a heath-type or moorland vegetation. A few attempts have been made to define this zone by species distribution but this criterion is also imprecise due to topographical microhabitats (Coe 1967). Troll (1958) recommended replacing the term alpine with nival and subnival, terms which correspond to above and below the permanent snow line, respectively. Wade and McVean (1969) adopted subnival from Troll when they compared the vegetation of the upper elevations of Mt. Wilhelm in New Guinea with the vegetation of high mountain areas north of the Antarctic Circle. However, Coe (1967) points out the term alpine is still very much a part of the literature and can be used in the broader meaning of "high mountain" when applied to tropical areas.

Altitudinal zonation in the tropics is also complicated by its three-dimensional character which involves not only temperature relations associated with latitude and altitude, but also precipitation. The sequence of vegetation types in the high Andes corresponds with a moisture gradient going from the Paramos in the north to moist Puna, dry Puna, thorn Puna, and finally desert Puna in the south (Troll 1966). High mountain areas in East Africa have been arranged in order of wetness which is said to account for the differences between equivalent altitudinal zones (Hedberg 1951). The definition of wetness, however, can also present a problem and should be defined in terms of the number of humid months rather than according to average annual precipitation. The morphology, stature, and structure of tropical alpine vegetation can be correlated with the temporal pattern of rainfall (Troll 1958). The temporal distribution of precipitation and its relationship to temperature in determining the climate of an area can be viewed graphically by the use of the climate diagram method of Walter (1963).

The problem of defining altitudinal zonation on tropical high mountains, then, is threefold. First, the upper limits of forests and trees, usually well definable in temperate areas, is not always clearly indicated on tropical mountains. Illustrative of one aspect of this problem are the tree-like, herbaceous forms growing at high elevations. They would be considered trees when classified by height but they are clearly related to herbaceous species. Second, the life form of many woody species of tropical mountain plants changes from trees to bushes and low shrubs in adaptation to climatic severity. If such species are the uppermost trees, it becomes difficult to demarcate the treeline. Such a species in Hawai'i is mamane (Sophora chrysophylla). Last, the ecological conditions of the forest and tree limits are not well defined. Decreasing temperature with increasing altitude, of course, accounts for the basic zonation, but large variations in rainfall in the tropics make temperature important in precipitation effectiveness (incident precipitation relative to soil moisture available to plants). Local variation in elevation of the timber line, if recognizable indicates that factors other than temperature and rainfall are also involved. Such factors include frequency of mist and clouds, frequency of frost and thaw, exposure to local winds, physical properties of the different substrates, and relative exposure to biotic influences such as herbivory (grazing, browsing, etc.) (Troll 1958). Substrate age and geologic history are other factors.

Plant Community Types

Similar plant communities have been described at equivalent elevations in different tropical alpine and subalpine environments. This resemblance is the result of certain outstanding environmental factors which had an evolutionary impact on the similarity of plant life forms. Characteristic community-types of these tropical high mountain areas include ericaceous (heath-like) scrub, tussock (bunch grass) grassland, arborescent (tree-like) and rosette life forms, and high altitude desert. However, differences are observed between areas due to a complex of local factors that are peculiar to any given area.

Ericaceous Scrub

The ericaceous scrub community-type can be generally described as consisting of evergreen, globose-shaped shrubs, many of which are in the families Ericaceae (includes 'ohelo) and Epacridaceae (includes pukiawe). High mountains of East Africa have an "ericaceous belt" in common whose similarity is indisputable despite physiognomic (physical appearance) differences related to climatic and edaphic (substrate) factors (Hedberg 1951). The "upper alpine belt" on Kilimanjaro was described as characterized by Ericaceae 0.5 to 1.0 m tall (Walter 1971). Salt (1954) calls the "heath formation" the most common plant cover on the same mountain and recognized six floristic communities related to slope and substrate within this formation. On Mt. Kenya, the "Ericaceous zone" has been recognized as being composed of three habitat types that are related to substrate (Coe 1967). On the much more humid Ruwenzori, the vegetation of the Ericaceous belt has been termed a "heath forest" which was divided into two floristic types, one dominated by species of Erica and the other dominated by species of Philippia occurring at higher elevations than the Erica-dominated type (Ross 1955).

In South America, three of the nine life forms characteristic of high altitude areas of the Andes included evergreen scrub with dense foliage of small scale-like or rolled leaves, evergreen broadleaf scrub, and scrub with woolly leaves (Troll 1966). In the Puna, a seasonally dry area of the southern high Andes, two provinces were distinguished of which one, the "puna province," was characterized by nanophanerophytes (dwarf trees less than 2 m tall) near 1 m tall with the Compositae, (daisy family), Solanaceae (nightshade family), Verbenaceae (includes Lantana) being the most important families forming two floristic communities (Cabrera 1966).

In the Paramos, a continuously humid area of the northern high Andes, a "Subparamo" formation occurring above the timber line forest has been described as consisting of shrubby species composed of genera common to other tropical high mountain areas (Cuatrecasas 1966).

The ericaceous community-type is also present in several high mountain areas of Asia. On Reunion Island in the Indian Ocean, ericaceous vegetation dominated by Philippia montana was composed of three main plant communities whose physiognomy and floristic structure were closely related to edaphic factors (Cadet 1974). In the Himalayas, dwarf rhododendron and juniper dominate communities up to about 5200 m (17,000 ft.) elevation. These communities were divided by Swan (1961) into wet and dry types. Also, a "shrub rhododendron" community was recognized at lower elevations. In the high mountains of Malaysia, Ericaceae often dominate in scrub-forests and in the alpine heath (van Steenis 1934-35, 1962). On Mt. Wilhelm, New Guinea, Wade and McVean (1969) note that species of both Ericaceae and Epacridaceae are characteristic elements of the alpine and subalpine scrub communities.

In Hawai'i, this community-type also contains a significant and sometimes dominant epacridaceous (similar to or in the plant family Epacridaceae) element from the genus Styphelia (pukiawe). Krajina's (1963) xerophytic (drought tolerant) scrub zone has been differentiated into three vegetation cover-types on Mauna Kea (Mueller-Dombois and Krajina 1968). On Mauna Loa, this community-type is represented by four described vegetation-types and several large-scale map units (Mueller-Dombois and Fosberg 1974).

Tussock Grassland

Another community-type characteristic of tropical high mountains is composed of tall bunch grasses known as tussock grasses. These tussocks are about 0.5 to 1.0 m or more tall, have about the same diameter, and look somewhat like sedge hummocks. The leaves are sclerophyllous (stiff and/or hard) and persist for long periods after dying and turning yellow. Genera that have tussock grass species include Festuca, Deschampsia, Danthonia, Stipa, Calamagrostis, and Andropogon (Walter 1971).

In the East African mountains, "tussock grasslands" are identified as one of five community-types occurring in the "alpine belt" (Hedberg 1951). On Kilimanjaro, a sedge and grass community is found on flat and wet ground and is mixed with a shrub species on gentle slopes in a "bog formation" (Salt 1954), and a typical tussock grassland on peaty soil is described as the dominant vegetation cover of the lower alpine belt (Walter 1971). Tussock grasses cover by far the larger part of the surface of the "alpine zone" and occur in flat, damp bogs and in open spots on weathered and eroded ridges in the "lower alpine zone" of Mt. Kenya (Coe 1967).

In South America, the Paramo is characterized by tall bunch grasses with scattered shrubs and arborescent life forms according to prevailing edaphic factors (Cuatrecasas 1966, Walter 1971). Further south, in the Puna, the "high-andine province" has been described as characterized by xerophytic caespitose (drought adapted bunch) grasses (Cabrera 1966). Thus, "tussock-like bunch grasses" have been included as one of the nine major life forms characteristic of the high Andes (Troll 1966). In the Himalayas, a "xerophytic alpine" association on slopes and scree areas includes tussock grasses (Swan 1961). Grassland is also one of two community-types of alpine areas in Malaysia (van Steenis 1962). Wade and McVean (1969) describe both alpine and subalpine tussock grasslands on Mt. Wilhelm, New Guinea.

In Hawai'i, tussock grasslands have been described on the island of Hawai'i with native grasses dominant on Mauna Loa and introduced grasses dominant on Mauna Kea (Mueller-Dombois and Krajina 1968). The ecology of the tussock grassland on the northeast outer slope of Haleakala has been studied in some detail (Forehand 1970).

Arborescent and Rosette Life Forms

Equally typical of tropical high mountains are arborescent plants that can be separated into two types based on growth form. Woolly rosetted species with tall, thick, and sparsely branched trunks are referred to as "woolly-rosetted" plants. Lower growing species with a single rosette and having candle-like woolly inflorescences are referred to as "woolly-candle" plants (Troll 1966). Although many authors have noted these peculiar growth forms, little work has been done to learn what factors or roles are associated with these modifications. It has been suggested by Coe (1967), however, that the rosette habit is related to the inhibiting effect on elongation of internodes produced by daily temperature changes and that this habit of growth functions in several ways to protect the plant from temperature extremes.

This life form is represented by species of Senecio and Lobelia on the high mountains of East Africa and in the highest parts of Ethiopia (Troll 1958). On Kilimanjaro, these same two genera characterize an "upper alpine belt" (Walter 1971), and Senecio spp. also form communities in association with broken rock faces in the "heath formation" on the same mountain (Salt 1954). On Mt. Kenya, several species of both Senecio and Lobelia form communities in both the lower and upper alpine zone. The presence of one of these species, Senecio keniodendron, defines the upper alpine zone (Coe 1967). Thus, Hegberg (1951) identifies an "arborescent Senecio forest" as one of five major community-types common to all the high mountain areas of East Africa. These giant, woody Senecios and Lobelias of East Africa have been studied with regard to their evolution, morphology, and the biogeography of related species, especially as related to the taxonomy of these plants. Mabberley (1973, 1974a, 1974b, 1975) wrote a series of articles on these aspects which also include discussions on non-alpine species.

In South America, the Paramo vegetation includes stands of the woolly-rosetted species of the genus Espeletia (Cuatrecasas 1966; Walter 1971). Also occurring in the high Andes are species of woolly-candle plants from the genera Lobelia and Lupinus in the Paramos of Colombia and the Puna of Peru. Species of the genus Puya (Bromeliaceae) occurring in the Puna of Bolivia also form woolly-candel plants (Troll 1958). In Asia, Anaphalis javanica which occurs in the high mountains of Malaysia corresponds to the woolly-rosetted form and the woolly-candle form is represented by Sausoura and Crepis in the Himalayas (Troll 1958; Walter 1971).

In Hawai'i the woolly-candle form is represented by several species of Argyroxiphium, the silverswords and greenswords. Thought to be widely distributed at one time on the high mountains of both Maui and Hawai'i (Ruhle 1959; Mueller-Dombois and Krajina 1968; Larson 1969), the silverswords are now very restricted in their distribution and have been entirely eliminated in most areas due to the activities of humans and introduced feral grazing animals (Ruhle 1959; Mueller-Dombois and Krajine 1968; Larson 1969).

High Altitude Desert

At very high elevations on tropical mountains, environmental conditions become so extreme that plant cover becomes sparse or absent altogether, and soil and vegetation formation processes proceed very slowly. These areas are therefore referred to as alpine stone deserts or, more generally, high altitude deserts. The dominant environmental factor that determines the extent of this community-type is nightly frost which makes plant invasion difficult (Troll 1966). On Kilimanjaro in East Africa there occurs a gradual transition from ericaceous heath vegetation to an "alpine desert" at about 4250 m (14,000 ft.) with plants growing in sheltered positions and having a total plant cover of less than 5% (Salt 1954; Walter 1971). On Mt. Kenya, the "nival zone" is described as a region of recent glacial retreat with the earliest stages of plant colonization. Plants are small in number, stunted, and invariably grow in sheltered situations (Coe 1967).

In Bolivia, South America, few plants occur above 4700 m (15,400 ft.) due to the daily occurrence of night frost (Troll 1966). In the Paramo region of the northern Andes, a "superparamo" vegetation-type has been described above 4500 m (14,700 ft.) elevation which was characterized by the scarcity of plants growing on the sandy and gravelly soil of that zone (Cuatrecasas 1966). In the high Himalayas of Asia, two of six ecological zones described were an "aeolian zone" and an "alto-alpine zone." In the aeolian zone, organisms that live on wind blown debris exist but no flowering plants are present. In the alto-alpine zone, flowering plants grow only at the bases of rocks (Swan 1961). On the high mountains of Malaysia, the "alpine zone" was described as a stone desert with mosses, lichens, and a few grasses and sedges (van Steenis 1934-35).

On Mauna Loa in Hawai'i three vegetation cover-types were described as high altitude desert communities or habitats. These were named a vegetationless stone desert, a Racomitrium moss desert, and a Vaccinium-Styphelia low-scrub desert. The corresponding vegetation cover-types on Mauna Kea were described as a stone desert with occasional crustose lichens, an Agrostis-Trisetum grass desert, and a Styphelia low-scrub desert (Mueller-Dombois and Krajina 1968). The vegetation-types on Mauna Loa are also reflected in map units on a large-scale vegetation map of Hawaii Volcanoes National Park (Mueller-Dombois and Fosberg 1974).

From the above comparisions of tropical alpine and subalpine ecosystems, it can be seen that tropical high mountain communities are structurally similar and are characteristic of basic ecological zones determined by factors related to increasing elevation, such as decreasing temperature and the associated frequency of night frost, changes in air pressure, and changes in radiation climate. However, differences in physiognomy (physical appearance) and altitudinal range of similar plant communities are observed and these are a function of a complex of local factors superimposed on the elevational factors. These factors include amount of precipitation, frequency of cloud mist, slope, chemical and physical properties of the soil and bedrock, and biotic factors, particularly the plant species present in the area.

HALEAKALA NATIONAL PARK CRATER DISTRICT

Geography

Haleakala National Park is located in the southeastern part of the island of Maui in the Hawaiian Archipelago, at latitude 20°45'N, and longitude 156°12'W. This eastern part of the island is formed by the large shield volcano of Haleakala. The area under consideration is the Crater District which incorporates Haleakala Crater (12 km [7.5 miles] long and 4 km [2.5 miles] wide), small adjacent segments of the outer slopes, and portions of two broad erosional depressions, called gaps (Fig. 1). Ko'olau Gap faces northeast and opens into Keanae Valley which runs to the ocean. Kaupo Gap faces south and opens into the pastureland of Kaupo Ranch. Kipahulu Valley, lying east of the study area and facing southeast, was excluded from this study since it will be described in a separate series of studies.

Structures on the northwest outer slope include the Park Headquarters, the stables, the Red Hill observatory, the old Civilian Conservation Corps Camp, the visitor center, and various scientific facilities located near the summit. Three visitor cabins are inside the Crater. These are Holua Cabin at the west end near Ko'olau Gap, Kapalaoa Cabin on the south central Crater floor, and Paliku Cabin at the extreme eastern end. A ranger cabin is also at the east end near Paliku Cabin. Access to the Crater District is by a narrow, winding, 19 km (12 mile) mountain road (State Highway #378) which ascends the northwest slope of Haleakala and connects to standard highways leading to the rest of the island of Maui. The Crater District is 45 km (28 miles) from the city of Kahului and 48 km (30 miles) from Wailuku (county seat). Elevations in this portion of the park range from 1144 meters (3760 ft.) to 3055 meters (10,023 ft.) above sea level.

Geology

Haleakala Crater, 12.1 km (7.5 miles) long, 4.0 km (2.5 miles) wide, and up to 915 meters (3,000 ft.) deep, is the large erosional summit depression on Haleakala. A general history of the geological formation of Haleakala has been given by Macdonald and Abbott (1970) and can be found in various other sources (Ruhle 1959, Larson 1969). The mountain was formed by three series of volcanic activity from Haleakala Volcano. The first two are known as the Honomanu volcanic series which occurred during the Tertiary, and the Kula volcanic series which occurred during the Pleistocene. These two volcanic series built up a large symmetrical shield volcano, much like Mauna Kea and Mauna Loa on Hawaii, whose summit may have been up to 915 meters (3,000 ft.) higher than the present crater rim.

At the end of the Kula eruption series, volcanic activity became infrequent or perhaps ceased. Water began to cut deeply into the mountainsides forming valleys all around. Keanae, Kaupo, Kipahulu and Waihoi valleys became particularly large eroded areas and they still exist today in essentially this form. Keanae and Kaupo streams had the shortest and steepest courses and eventually cut into the very center of the mountain. Continued erosion resulted in these two valleys fusing into a single huge erosional depression that extended across the entire mountain top, divided only by a low, narrow ridge.

In geologically recent times, i.e. within the last 15,000 years, the third period of volcanic activity began. This series of lavas and cinder cones is known as the Hana volcanic series. These lava flows covered the east and west slopes of the volcano and the floor of the depression. Great lava flows pushed through Ko'olau and Kaupo gaps to the sea. The ridge that divided the two great valleys is masked by large flows and cinder cones. The most recent eruption, estimated to have occurred about 1790, was on the southwest rift and is represented by two bare, black flows above La Perouse Bay.

Soils

As would be expected from the recency of volcanic activity on Haleakala, soils are young and relatively undeveloped. Almost all the soils of Haleakala have been classified (Larson 1969) as lithosols (rock) or regosols (cinder and ash), with some latosolic soils (brown forest soils) occurring near the Park's northwest boundary being the only intrazonal (differentiated) soil in this section of the Park (U.S. Soil Conservation Service 1955). Maps of the distribution of various soil types in the area are available from the Soil Conservation Service's Soil Survey (1972). These maps are based primarily on reconnaissance survey mapping units for the Park and indicate an ash, cinder, rock or rock outcrop substrate or rough mountainous terrain for almost all of the Crater area. Soil classification and data for the area are very incomplete and general in nature and offer little useful information for ecological studies.

Climate

The climate in Haleakala varies greatly with dry, moderately warm summers and cool, wet windy winters being characteristic. At Haleakala Ranger Station, mean monthly temperature ranges from 9.6°C (49°F) in February to 13.4°C (56°F) in August, a difference of only 3.8°C (7°F). Cloudy conditions are typical during midday all year. Snow has been recorded in the summit area, but only rarely in the winter (Larson 1969).

The climate of the area has been described by Blumenstock and Price (1967). It is greatly influenced by the temperature inversion layer which accompanies tradewinds, which are present 50% to 70% of the time. The inversion layer is a result of a slight increase in temperature which may extend several hundred feet upslope before the temperature begins once more to decrease upward, as is usual in the atmosphere. When present, the height of the inversion layer varies from day to day, but it is usually between 1525 meters and 2130 meters (5,000-7,000 ft.) elevation. The inversion layer supresses the vertical movement of the air thus restricting cloud formation to the zone beneath the inversion. This boundary also results in a relative humidity generally below 40 percent above the cloud layer and occasionally as low as 10 or even 5 percent.

The upper slopes of the high mountains are considered to receive some of the lowest amounts of precipitation in the state (Blumenstock and Price 1967). Average annual precipitation does, however, vary greatly within the Park. Ko'olau Gap at 2100 meters (6890 ft.) elevation, averages 2,000 mm (79 inches) precipitation while the summit averages only 300 mm (31.5 inches) at 3,000 meters (9840 ft.) elevation (Kobayashi 1973). Detailed rainfall and temperature records for the area are scarce and fragmentary. Taliaferro (1959) includes mean minimum, mean maximum and median rainfall figures by month for only two stations within the Park boundary. Four rain gauges and seven temperature shelters were maintained for fourteen months (December 1970-February 1972) on the Crater floor in connection with a study of the silversword populations occurring there (Kobayashi 1973). Mr. Bernard Meisner of the University of Hawaii Meteorology Department is in the process of collecting rainfall and temperature data to update climatic maps for the state. Some information for the Crater area was obtained from computer tapes and more information may become available when research efforts are concentrated on the island of Maui.

Flora

The Hawaiian Islands are the most remote high volcanic islands in the world. They are virtually alone in the center of the North Pacific, being almost 4,000 km (2500 miles) from North America to the east and 5635 km

(3500 miles) from the Marianas Islands to the west. The closest high volcanic islands, the Marquesas, lie 3220 km (2,000 miles) to the south (Carlquist 1970). Thus dispersal to Hawaii had to be over large distances of ocean, since geological evidence indicates that no land existed at lesser distances even during earlier periods. This isolation has allowed the relatively few successful arrivals to evolve seemingly strange adaptations to fill niches (role of an organism in the ecosystem) left unoccupied by the usual continental occupants that were less successful at long distance dispersal (Carlquist 1970).

Therefore, many alpine plants typical of other high mountain regions in the world are absent from Haleakala. Many of the plants on Haleakala are representatives of north temperate zone groups. This is not surprising since the cooler temperatures of higher latitudes occur only at higher elevations in the Hawaiian Islands. North temperate zone taxa represented in Hawai'i include Fragaria, Artemisia, Silene, Vaccinium, and the Madiinae, the subtribe of Compositae including Argyroxiphium and Railliardia (Carlquist 1970, Carr 1978). Similarly, some genera show affinities to south temperate zone groups such as Coprosma, Santalum, Wikstroemia and probably Sophora. Another characteristic is that many high-altitude genera in Hawaii occur also at lower elevations. These include Styphelia, Dodonaea, Santalum and Sadleria (Carlquist 1970).

The Crater District flora also includes several exotic species introduced by man and his domestic animals. These introductions have resulted in native species losing ground to invading forms with up to 100 percent alteration in flowering plant species composition in some areas. Some of the more obvious and widespread of these genera include Eupatorium, Hypochoeris, Oenothera, Pennisetum, Pinus, Rumex and Eucalyptus. A list of exotic species has been compiled for the Park (Larson 1969).

The flora of the Crater is fairly well known because of studies focusing on the special adaptations mentioned above and the native species and species associations that occur in the area. Examples of candidate endangered native species found in the study area include Viola tracheliifolia, Geranium arboreum, and Stenogyne crenata. Detailed plant lists for the Crater District that include habitat notes are being compiled in a three year resources basic inventory study by the Cooperative National Park Resources Studies Unit of the University of Hawaii (CPSU/UH) (Berger et al. 1976, Stemmermann et al. 1979). Since this study includes both vascular and nonvascular plants plus comments on each species (e.g. endemic, exotic, distribution, abundance, etc.), it is a significant expansion of the floristic knowledge of the area over previous works that only include species that are common or typical of the area (Ruhle 1959, Carlquist 1970, Mitchell 1945, Skottsberg 1931, Hubbard and Bender 1960). A detailed plant list has been compiled for the northeast outer slope of Haleakala by Henrickson (1971). However, this area, although closely related to the Crater floristically, is only marginal to the study area of this paper.

Fauna

The Park is rich in insects most of which are endemic species and are very limited in their distribution. Many are associated with specific endemic plant species and are highly vulnerable to extinction. Of the introduced insects in the area, the large blowflies which breed in the carcasses of goats are the most conspicuous since they are a considerably nuisance (Ruhle 1959). The CPSU/UH Resources Basic Inventory also includes a survey of the insect species of the Crater area (Berger et al. 1976, Beardsley, forthcoming).

The bird life of the Crater includes several species in the endemic Hawaiian family Drepanididae. These include the 'Apapane (Himatione sanguinea), the 'I'iwi (Vestiaria coccinea), and the 'Amakihi (Loxops virens wilsoni). Other native birds common in the Park include the Hawaiian Goose or Nene (Branta sandvicensis) once near extinction but now recovering through a restoration program, the White-tailed Tropic Bird (Phaethon lepturus), the Golden Plover (Pluvialis dominica), and the Hawaiian Owl or Pueo (Asio flammeus) (Ruhel 1959, Larson 1969). Also native is a ground nesting seabird, the Dark-rumped Petrel (Pterodroma phaeopygia sandwichensis) an endangered species which has been the subject of some sporadic studies (Larson 1967) and census counts by NPS personnel, Mr. J. Kunioki and J. Kjargaard.

Introduced bird species are quite numerous and more commonly seen than native birds. These include the Japanese White-eye (Zosterops japonica), Ring-necked Pheasant (Phasianus colchicus), Chukar (Alectoris graeca), House Finch (Carpodacus mexicanus), Skylark (Alauda arvensis), Mockingbird (Mimus polyglottus), Barn Owl (Tyto alba), California Quail (Lophortyx californicus) and House Sparrow (Passer domesticus) (Ruhle 1959).

There are no mammals native to the Hawaiian Islands with the exceptions of the Hawaiian bat (Lasiurus cinereus semotus) (Larson 1969) and the Hawaiian monk seal (Monachus schauinslandi). When Polynesians arrived in Hawaii, they brought pigs, dogs and rats which probably established feral populations that extended into the Park. After Captain Cook's arrival, many mammals were introduced including goats, pigs, cattle, horses, sheep, cats, dogs, mice and rats. Also, mongooses were imported with the intention of controlling the rat population. Horses, sheep and cattle though once feral, no longer occur as wild populations in the Park (Ruhle 1959, Larson 1969).

The feral goat is the most obvious mammmal in the Crater District and once numbered into the thousands (Larson 1969), causing much damage to the vegetation and thereby speeding erosion. The goat population was studied by Yocum (1967) as to its distribution and ecological relationship to the Crater District's environment. The Park Service has made some limited progress in the control of the introduced mammal populations through controlled shooting of goats and pigs and trapping of dogs, cats, mongooses and rodents (Larson 1969).

Ecology

There have been few ecological studies in the Crater region, and of those that have been undertaken none addressed the ecology of Haleakala Crater as a whole. A vegetation map has been produced at a scale of approximately 1:62,500 that distinguished only four types of vegetation based on its structural character: scattered shrub and barren areas, shrub, shrub-savannah, and marginal rain forest (Larson 1969). Several plant communities have been identified for the northeast outer slope of Haleakala which are similar to communities found within the Crater. Although floristic composition was discussed in the text of the paper (Vogl 1971), the units were again based primarily on structural character and were identified as tussock grassland, alpine bog, heath-scurb, cloud forest, and montane rain forest. In a related study (Forehand 1970), the phytosociology of the tussock grassland community-type composed mainly of Deschampsia was studied. In her structural-floristic analysis Forehand used twenty-one sample stands to obtain percent frequency, percent cover, and density per acre for all species. She defined five "site-types" within this community. The five site-types were the level grassland site-type, the sloping grassland site-type, the heath ecotone site-type, the fern ecotone site-type, and the mid-ecotone site-type. Also, the effect of pig digging was noted and soils data were collected.

Other studies have been concerned with the ecology of specific organisms found within the Crater. The silversword (Argyroxiphium sandwicense DC.), once common throughout the Crater and on the outer slopes of Haleakala (Ruhle 1959, Larson 1969), has had its range restricted to cinder cone areas on the western crater floor and to a small area, now enclosed and specially protected by the National Park Service on the outer slope (Kobayashi 1973). This dramatic decline in the population is commonly attributed to vandalism by humans and to grazing pressure by feral goats (Ruhle 1959, Larson 1969). The ecology of the silversword in what is left of its range has been thoroughly studied by Kobayashi (1973) in a Ph.D. dissertation at the University of Hawaii. He found that the silversword is well adapted to its remaining habitat in Haleakala since it has xerophytic (drought resistant) features such as tomentose (densely covered with matted, wool-like hairs) succulent leaves and an ability to sustain regeneration under the dynamic substrate conditions found on larger cinder cones that eliminate all but a few exotic or endemic species.

The distribution, density and ecology of the Crater's feral goat population has been studied by Yocum (1967). The goats' effect on the vegetation and substratum erosion was summarized as:

a. Overgrazine of the native plants.
b. Elimination of some native plants, thus eliminating ground cover.
c. Disturbance of the soil by sharp hooves.
d. Complete elimination of plants from saddles, hogback ridges, goat trails, and along the rim of the Crater by feeding or loitering herds of goats.
e. Pawing of the ground by billies before lying down.
f. Increased erosion by rainfall of soils disturbed by goats.
h. Slides started by grazing goats.

i. Slides started by goats of all ages playing on the exposed cinders and basalt.

j. Slides started by rocks dislodged by feeding goats.

The most dramatic examples of goat and pig accelerated erosion occur on the flat tops of Pohaku Palaha and Kuiki, east of Paliku (Fig. 1). In these areas several acres of exposed rocks are dotted here and there with mesa-like clumps of soil showing that at one time these areas were covered with six or more feet of topsoil held in place by native shrubs and grasses (Yocum 1967).

CONCLUSIONS

Though little research has been addressed to the tropical alpine and subalpine ecosystem of Haleakala as a whole, it is similar to other areas in the tropics. The woolly candle plant dominated community type was probably a significant vegetation unit before it was decimated by man and goats. The flora of the Hawaiian alpine and subalpine ecosystems are more depauperate than similar continental areas due to the extreme isolation of the island group.

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MINUTES OF THE REGULAR MEETING OF DECEMBER 5, 1977

The meeting was called to order at 7:40 p.m. Dr. Lamoureux presided in the place of Mr. Ted Green who was away on a business trip. The minutes of the previous meeting were read and approved. The annual 1977 reports of the secretary and treasurer were presented.

The nominating committee headed by Dr. Dan Palmer announced the new slate of officers for the year 1978. The following candidates were nominated.

President:	Mr. John Obata
Vice-president:	Ms. Evangeline Funk
Secretary:	Ms. Winona Char
Treasurer:	Dr. Charles H. Lamoureux
Directors:	Mr. Ted Green (Past President) Dr. Gerald D. Carr

The Society members approved the selection of the new officers on an unanimous voice vote.

It was suggested that the Society once again meet at the old Hawaiian Sugar Planters' Association Agee Hall. Some members expressed disatisfaction with the availability and cost of parking on the University Campus where the meetings are currently held. It was then proposed that the Executive Committee look into this matter.

Ms. Lisa Croft announced the dates for the South Kona Research Project (a National Science Foundation sponsored Student Oriented Studies Program) slide show presentation.

The "Plant-of-the-month" talk was given by Keith Woolliams who spoke on Hibiscadelphus distans.

Dr. Lamoureux then introduced the speaker for the evening, Dr. Isabella A. Abbott, who spoke on "The influence of major food plants on the social system of old Hawaii".

Winona P. Char, Secretary

MINUTES OF THE REGULAR MEETING OF JANUARY 9, 1978

The meeting was called to order by President Obata promptly at 7:30 p.m. The new officers were presented to the rest of the members. Mr. Obata is a teacher at Kawananakoa School who has a great deal of experience on the flora of Oahu. He has also done extensive research on the propagation of endemic flowering plants. Ms. Funk is a graduate student in the Botany Department where she is working on the fiber plants used in making Hawaiian tapa. She has hiked extensively on Oahu as well as the outside islands. Ms. Char is currently completing her study on the genus Sesbania in the Hawaiian Islands. She has also been involved in or written numerous Environmental Impact Statements particularly on Oahu. Dr. Lamoureux is well-known for his interests in the natural history of the islands as well as his extensive experience in the flora of all islands. Mr. Green has directed the Honolulu City and County Parks and Recreation Department. His horticultural interests are directed at the genus Hoya. Dr. Carr is currently working on the taxonomy of the Hawaiian tarweeds using cytogenetical approaches to resolve the extensive hybridization that appears to have occurred within the group.

Business brought up during the previous Executive Board Meeting was discussed by the President. Some of the points brought up were as follows:

1. On the proposal that we move the monthly meetings to the old Hawaiian Sugar Planters' Association Hall: Upon further inquiry it was found that Agee Hall is not available on Monday nights.
2. Winners of the Science Fair will receive copies of J. F. Rock's Indigenous Trees of the Hawaiian Islands from the society.
3. A request was made for articles and any bits and pieces of news about plants that could be used in the Newsletter. It was announced that the latest edition of the Newsletter was forthcoming.
4. April has been designated as "Plant donation month".
5. Lisa Croft will be our Conservation Committee Representative during this legislative session.
6. The President proposed that we give an award for "Botanist of

the Year". It was suggested that perhaps we should modify that title to "Significant contributor to the field of Botany in Hawaii". The motion was approved and carried.

7. It was announced that door prizes would be given away during punch time.

Much to the surprise of some and under threats of choking necks the President announced future field trips to Ka'ena Pt. and to several botanic gardens and arboreta.

The meeting was then turned over to the Vice-president who introduced the "Plant-of-the-month" speaker, Dr. Gerald Carr, who spoke on the endemic genus Lipochaeta. The Vice-president then introduced the speaker for the evening Mr. Paul R. Weissich, director Honolulu Botanic Gardens, who spoke about "A collecting trip to Latin America".

Winona P. Char, Secretary

MINUTES OF THE REGULAR MEETING OF FEBRUARY 5, 1979

The meeting was called to order by President Obata at 7:30 PM.

It was announced that the editor of the Newsletter and Dr. Dan Palmer are seeking any interesting articles on botany, ethnobotany, endangered plants, etc. The Newsletter is also seeking to expand its general appeal to the membership of the Society. The editor is particularly interested in notes on the activities of the members, visitors to the islands, honors and awards to Society members, etc. The Newsletter can also be used as a vehicle to inform members of one's research interests so that specimens and records of unusual interest can be directed to those most concerned.

A safari to Ka'ena Pt. led by Drs. Carr and Herbst will take place on Sunday , March 12. An April safari to the Koko Crater Botanic Garden is planned. This trip will be led by Dr. Paul Weissich who is the Director of the Honolulu Botanic Gardens.

In response to a letter from Rep. Russell Blair on environmental affairs, President Obata recommended that the legislature focus on the control of noxious exotic plants.

Dr. Dan Palmer reported on the Native Plant Committee. This committee, whose members are Mr. John Obata, and Drs. Dan Palmer, Gerald Carr, Derral Herbst and Charles Lamoureux, are responsible for the "Plant-of-the-month" presentations as well as seeking information on rare and endangered Hawaiian plants.

The meeting ended at 7:50 PM.

The Vice-president introduced the "Plant-of-the-month" speaker, Dr. C. Lamoureux, who spoke about the genus Achyranthes. The vice-president then introduced the evening's speaker, Ted Green (past society President) who spoke on "Collecting in Melanesia".

Winona P. Char, Secretary

ST JOHN'S HAWAIIAN PLANT NOVELTIES SINCE 1972

Harold St. John
Bishop Museum
Honolulu, Hawaii

On October 18th, 1973 St. John's List and Summary of the Flowering Plants in the Hawaiian Islands was published as Memoir No. 1, of the Pacific Tropical Botanical Garden. Since this book was in press for two years, it did not include most of the plant novelties published in 1972 and 1973. Subsequently the author has published on a number of newly discovered Hawaiian plants. By request, he has prepared and here presents a list of the Hawaiian plant novelties that he has published since 1972, that are not included in the aforementioned book.

GRAMINEAE

Cenchrus laysanensis (F. Br. in Christoph. & Caum) St. John, Phytologia 31: 22-24, fig. 1, 1975. Kure, Midway and Laysan Is.

C. agrimonioides Trin., var laysanensis F. Br. in Christoph. & Caum, Bishop Mus., Bull. 81: 20, 1931.

Panicum gracilius (Skottsb.) St. John, Phytologia 36: 312, 1977. Kauai.

P. hillebrandianum Hitchc., var. gracilius Skottsb., Goeteb. Bot. Traedg., Meddel. 15: 296, figs. 118-124, 1944.

Panicum moomomiense St. John, Rhodora 78: 542-545. fig. 1, 1976. Molokai.

JOINVILLEACEAE

Joinvillea ascendens Gaud. ex Brongn. & Gris, Soc. Bot. France, Bull. 8: 269, 1861, is reestablished as the valid name of the Hawaiian species, and J. Gaudichaudiana is reduced to synonymy. Phytologia 40: 372, 1978.

PIPERACEAE

Peperomia plinervata St. John, Pacif. Sci. 30: 9-11, fig. 2, 1976. Hawaii.

Peperomia waihoiana St. John, Phytologia 34: 362-363, fig. 1, 1976. Maui.

URTICACEAE

Neraudia Cookii St. John, Pacif. Sci. 30: 7-9, fig. 1, 1976. Hawaii.

Urera konaensis St. John, Pacif. Sci. 30: 11-13, fig. 3, 1976. Hawaii.

AMARANTHACEAE

Achyranthes Nelsonii St. John, Pacif. Sci. 30: 13-15, fig. 4, 1976. Hawaii.

Alternanthera Menziesii St. John, reestablished. Phytologia 37: 476-478, 1977. Sandwich Is.

CARYOPHYLLACEAE

Schiedea membranacea St. John, Pacif. Sci. 26: 275-277, fig. 1, 1972. Kauai.

SAXIFRAGACEAE

Broussaisia arguta Gaud., var. arguta, f. ternata Forbes ex Skottsb., Goeteb. Bot. Traedg., Meddel. 2: 235, 237, 1926.

B. *arguta* Gaud., var. *arguta*, f. *ternatea* St. John, Phytologia 34: 147, 1976.

PITTOSPORACEAE

Pittosporum Monae Rock ex St. John, Phytologia 38: 93-95, 1977. Hawaii.

RUTACEAE

Pelea glabra St. John, Pacif. Sci. 26: 277-279, fig. 2, 1972. Kauai.

Zanthoxylum dipetalum Mann, var. Hillebrandii (Sherff) St. John, Rhodora 78: 73, 1976. w. Maui.

Fagara dipetala (Mann) Engler, var. *Hillebrandii* Sherff, Am. Journ. Bot. 45: 462, 1958.

Z. dipetalum Mann, var. Mannii (Sherff) St. John, Rhodora 78: 73, 1976. Kauai.

Fagara dipetala (Mann) Engler, var. *Mannii* Sherff, Am. Journ. Bot. 45: 462, 1958.

Z. hawaiiense Hbd., var. subacutum (Sherff) St. John, Rhodora 78: 73, 1976. Kauai.

Fagara hawaiiensis (Hbd.) Engler, var. *subacuta* Sherff, Am. Journ. Bot 45: 462, 1958.

Z. Hillebrandii Waterm., var. hiloense (Sherff) St. John, Rhodora 78: 73, 1976. Hawaii.

Fagara glandulosa (Hbd.) Engler, var. *hiloensis* Sherff, Am. Journ. Bot. 45: 462, 1958.

Z. kauaense Gray, var. kohalanum (Sherff) St. John, Rhodora 78: 73, 1976.

Fagara kauaiensis (Gray) Engler, var. *kohalana* Sherff, Am. Journ. Bot. 45: 461, 1958.

Z. konaense Gray, var. tenuifolium (Deg. & Sherff in Sherff) St. John, Rhodora 78: 73, 1976. e. Maui.

Fagara kauaiensis (Gray) Engler, var. *tenuifolia* Deg. & Sherff in Sherff, Am. Journ. Bot. 45: 461, 1958.

Z. maviense Mann, var. kaalanum (Sherff) St. John, Rhodora 75: 73. 1976.

Fagara mauiensis (Mann) Engler, var. *kaalana* Sherff, Am. Journ. Bot. 45: 462. 1958.

Z. maviense Mann, var. lanaiense (Sherff) St. John, Rhodora 78: 74, 1976. Lanai.

Fagara mauiensis (Mann) Engler, var. *lanaiensis* Sherff, Am. Journ. Bot. 45: 462, 1958.

Z. maviense Mann, var. maunahuiense (Sherff) St. John, Rhodora 78: 74, 1976.

Fagara mauiensis (Mann) Engler, var. *maunahuiensis* Sherff, Am. Journ. Bot. 45: 462, 1958.

EUPHORBIACEAE

Antidesma crenatum St. John, Pacif. Sci. 26: 279-281, fig. 3, 1972. Kauai.

Euphorbia celastroides Boiss., var. Nelsonii St. John, Pacif. Sci. 30: 15-17, fig. 5, 1976. Hawaii.

SAPINDACEAE

Sapindus Lonomea St. John, Pacif. Sci. 26: 283-286, figs. 5-6, 1972, Kauai.

S. Thurstonii Rock, reestablished. Phytologia 36: 312, 1977. Maui, Hawaii.

RHAMNACEAE

Alphitonia ponderosa Hbd., var. auahiensis St. John, Phytologia 35: 180, 1977. Maui.

var. costata St. John, Phytologia 35: 180, 1977. Oahu.
var. grandifolia St. John, Phytologia 35: 181, 1977. Kauai.
var. Kauila St. John, Phytologia 35: 181-182, 1977. Hawaii.
var. lanaiensis St. John, Phytologia 35: 182, 1977. Lanai.

MALVACEAE

Hibiscus Roeatus St. John (as *Roeatae*), Pacif. Sci. 26: 286-289, fig. 7, 1972. Kauai.

Sida Ledyardii St. John, Pacif. Sci. 30: 17-19, fig. 6, 1976. Hawaii.

S. Nelsonii St. John, Pacif. Sci. 30: 19-22, figs. 7-8, 1976. Hawaii.

VIOLACEAE

Isodendrion Christensenii St. John, Phytologia 40: 375-378, fig. 1, 1978. Kauai.

Viola lanaiensis Becker, resurrected, St. John, Phytologia 44: 324, 1979.

FLACOURTIACEAE

Xylosma crenatum (St. John) St. John, Phytologia 34: 147, 1976.
Antidesma crenatum St. John, Pacif. Sci. 26: 279, 281, fig. 3, 1972. Kauai.

MYRTACEAE

Metrosideros polymorpha Gaud.,
var. glaberrima (Lévl.) St. John, Phytologia 42: 216, 1979.
Nania polymorpha (Gaud.) Lévl., var. *glaberrima* Lévl., Fedde Repert. 10: 149, 1911. Kauai, Oahu, Hawaii.
var. glabrifolia (Heller) St. John, Phytologia 42: 216, 1979.
Nania glabrifolia Heller, Minn. Bot. Stud. 1: 866, 1897, Kauai.
forma obovata (Skottsb.) St. John, Phytologia 42: 216, 1979.
M. polymorpha Gaud., subsp. *glabrifolia* (Heller) Skottsb., forma *obovata* Skottsb., Goeteb. Bot. Traedg., Meddel. 15: 404, 1944.
var. haleakalensis (Rock) St. John, Phytologia 42: 216, 1979.
M. collina (J. R. & G. Forst.) Gray, subsp. *polymorpha* (Gaud.) Rock, var. *haleakalensis* Rock, Hawaii Bd. Agr. & For., Bot. Bull. 4: 56, pl. XXI, 1917. Maui.
var. hemilanata (Hochr.) St. John, Phytologia 42: 216, 1979.
M. collina (J. R. & G. Forst.) Gray, var. *hemilanata* Hochr., Candollea 2: 456, 1925. Kauai.

var. imbricata (Rock) St. John, Phytologia 42: 216, 1979.
M. collina (J. R. & G. Forst.) Gray, subsp. polymorpha (Gaud.) Rock, var. imbricata Rock, Hawaii Bd. Agr. & For., Bot. Bull. 4: 49, pl. XVII, 1917. Oahu.
var. incana (Lévl.) Rock, forma lurida (Rock) St. John, Phytologia 42: 417, 1979.
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MINUTES OF THE REGULAR MEETING OF MARCH 6, 1978

The meeting was called to order by President Obata at 7:34 pm.

It was voted to send $100.00 to the Wau Research Institute in New Guinea to be used specifically for their education program.

A vote to choose the date of the Koko Crater Tour was taken. It was decided that Saturday, April 15, will be the date for the Koko Crater tour.

President Obata has appointed Dr. Derral Herbst chairman of the committee to select the "Botanist of the Year".

Lisa Croft, our conservation committee representative, was asked to draft a statement on where the Society stands on conservation issues.

Funding from the State legislature for the Clidemia hirta (Koster's curse) eradication program is in jeopardy. Members were asked to help support the eradication program after a brief explanation of the problem. The species is a major weed on O'ahu. It is also established on the Big Island and has recently been found on Maui.

President Obata announced that membership secretary, N. Balakrishnan, is collecting membership dues for this coming year. All members were requested to pay their dues as soon as possible. The Society does not intend to send out reminders because the costs are too high. Any member who is in arrears for over two years will be struck from the membership rolls.

Books on botany are wanted by Ron Hurov. The books will be sent to Burma.

Dr. Clifford W. Smith will be our Science Fair representative this year.

Plant exchange month was held during this meeting instead of April as previously announced.

The Vice-president then introduced the "Plant-of-the-month" speakers for the evening. Joyce Davis spoke about the endemic orchid Platanthera holochila from the Alakai Swamp on Kaua'i. Steve Montgomery talked about his trip to French Polynesia and of the threat of an introduced weed to this area. The introduced weed, Miconia (a member of the Melastoma family) has the potential of becoming a serious pest like Clidemia is in the Hawaiian Islands.

Vice-president Funk then introduced the speaker for the evening, Dr. Douglas Yen of the Bishop Museum, who lectured on the "Cave Dwellers of the Philippines".

Winona P. Char, Secretary

ADAPTIVE RADIATION IN THE SILVERSWORD ALLIANCE--AN OVERVIEW

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The Haleakala silversword (Argyroxiphium macrocephalum Gray), one of Hawaii's most well-known and publicized endemic plants, is each year sought out by hundreds of tourists including many botanists from all parts of the world. However, from a biosystematist's point of view it is only one of a fascinating group of about 32 species in the genera Dubautia, Wilkesia and Argyroxiphium which collectively comprise a truly remarkable example of adaptive radiation.

In fact, the genus Dubautia (sensu Keck, 1936; St. John, 1950; cf. Sherff, 1935) has in the relatively short span of probably less than 15 million years (cf. Macdonald and Abbott, 1970 for a discussion of Hawaiian geology) evolved a spectacular diversity of forms capable of exploiting almost every conceivable terrestrial habitat in Hawaii. It has representatives from near sea level [D. scabra (DC.) Keck--250 feet elev.) to timberline (D. ciliolata (DC.) Keck var. juniperiodes (Gray) Keck--10,500 feet elev.] and from areas that receive less than 15 inches of annual precipitation (D. montana (Mann) Keck) to perhaps the wettest place on earth receiving about 500 inches of annual precipitation (D. waialealae Rock). These habitats range from very recent lava flows on Hawaii (D. scabra) to mature rain forests on Kauai (D. knudsenii Hbd.).

Two parameters involved in the adaptation of these species to habitats of differing water availability are leaf surface area and xylem vessel element dimensions (cf. Carlquist, 1974). The surface area of leaves (Fig's. 1 & 2) varies dramatically between species and there is a nearly perfect correlation between leaf size and water availability such that species with smaller leaves are found in drier habitats. The small-leaved species tend to be xeromorphic in other respects as well. For example, they have an increased volume to surface area ratio (are thicker), are often more fibrous (harder) and have less intercellular space than species occupying habitats with more moisture (cf. Carlquist, 1959).

Some of these same modifications also allow different species to exploit habitats with different light regimes. Thus the small-leaved species are usually found in areas of high insolation whereas large-leaved species are found in shaded rain forest habitats.

Another parameter is also important with respect to light relationships, i.e. the overall habit of the plant (Carlquist, 1970 provides habit illustrations which in most cases are accurate). Dry forest to rain forest species tend to be woody and tall with trunks up to about a foot in diameter and heights to 25 feet (*D. reticulata* (Sherff) Keck--dry to wet forest). One rain forest species (*D. latifolia* (Gray) Keck) has evolved the lianous habit which allows exploitation of light at higher levels by surmounting the canopy of surrounding species. Species of dry habitats tend to be of low stature and are somewhat scrubby in appearance. The smallest of these is *D. scabra* var. *scabra*, an almost herbaceous, sprawling, small-leaved pioneer on very recent lava flows (cf. Smathers and Mueller-Dombois, 1974).

The trends outlined above are not without exceptions as demonstrated by the fact that the species whose range includes the driest habitats (*D. montana*) is not the species with the smallest stature and leaves, nor is *D. waialealae* of the wettest habitat the species with the largest stature and leaves. Presumably there are other underlying physiological and genetical factors for these exceptions.

However, the trends are certainly obvious and hold even at the infraspecific level of variation. Thus, *Dubautia scabra* var. *scabra* has the smallest leaves and stature of its species and occurs in the driest habitats, whereas *D. scabra* var. *leiophylla* (Gray) Keck is intermediate in all the aforementioned respects while *D. scabra* var. *munroi* (Sherff) Keck is a giant, more woody and upright form of the species found in the continuously wet rain forest along the Olinda Pipeline Trail on Maui (cf. Fig 2 H, K, L).

In addition to the diversity encountered in the genus *Dubautia*, one must consider the variation exhibited by the genera *Argyroxiphium* and *Wilkesia* before the story of adaptive radiation of the silversword alliance is complete. *Argyroxiphium* includes species referred to as silverswords as well as those considered greenswords. The most common silversword (*A. macrocephalum*) is modally a monocarpic rosette plant which grows for a number of years before it finally produces its spectacular flowering stalk and dies.

As in other rosette plants of high elevations, the shape of the rosette and the silvery coating of hairs on the leaves of *A. macrocephalum* are presumably related to conservation of heat and moisture and protection of underlying tissue from harmful solar rays encountered at increasingly higher elevations (cf. Coe, 1967; Hedberg, 1964). The greenswords are at somewhat lower elevations, often in boggy areas. They lack the dense coating of silvery hairs, tend to branch more freely and usually have a rosette form less likely to be effective in modifying the heat, light and moisture parameters mentioned above. However, all investigated members of the genus *Argyroxiphium* share a distinctive internal leaf anatomy, presumably indicating a common ancestry of all Hawaiian sword plants (Carlquist, 1957).

Wilkesia is unique by virtue of its whorled, basally coalescent (sheathing) leaves, a condition approached in *Argyroxiphium*. However, *Wilkesia* lacks the unique leaf anatomy found in *Argyroxiphium* and also lacks rayed heads so common in the latter.

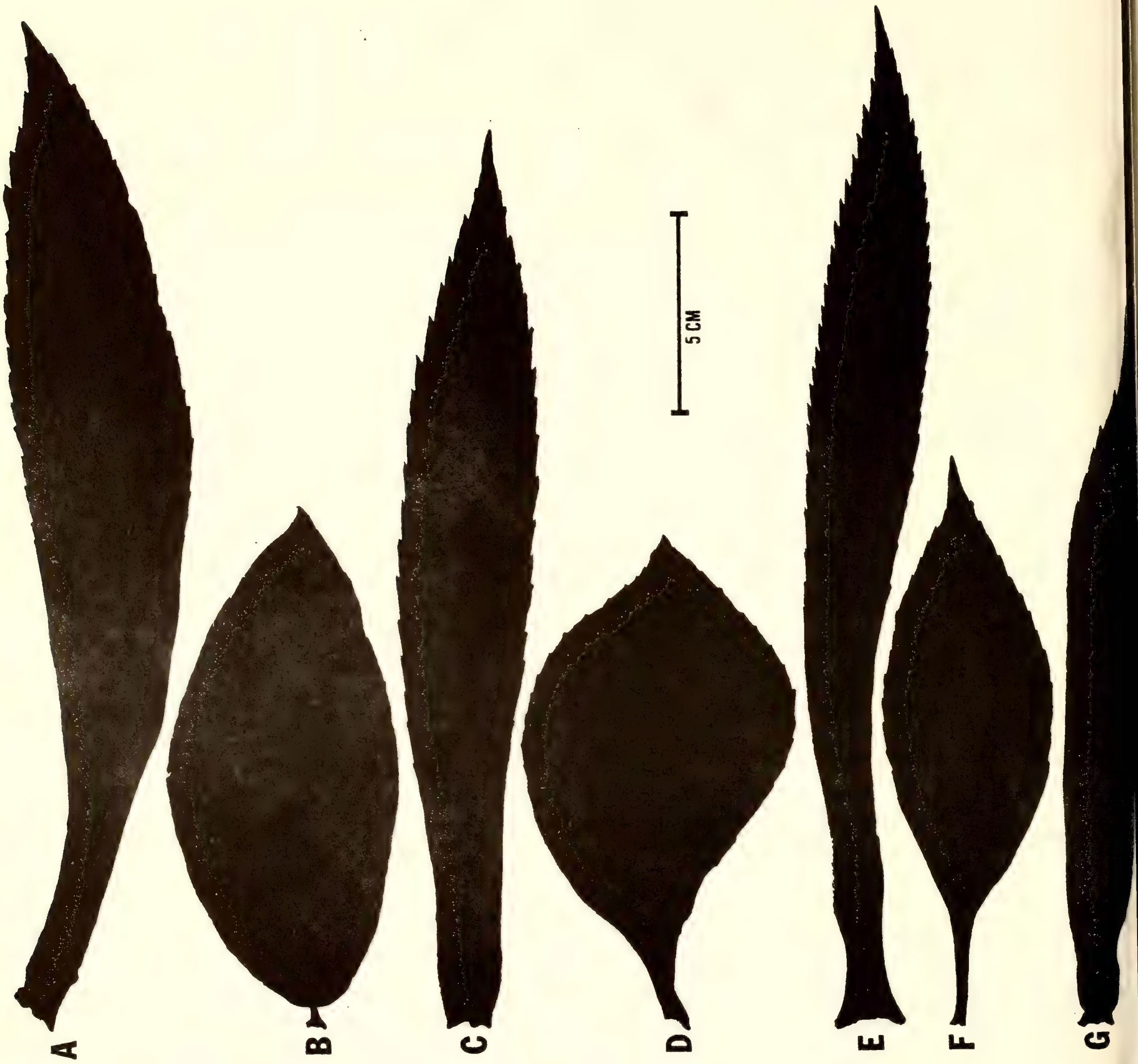

Figure 1. Leaves of *Dubautia* grown under uniform conditions and arranged according to descending surface area. A, *D. raillardioides*--rain forest; B, *D. latifolia*--rain forest; C, *D. plantaginea*--mesophytic forest; D, *D. laxa*--bog; E, *D. laevigata*--rain forest; F, *D. knudsenii*--rain forest; G, *D. microcephala*--rain forest.

In addition to the diversity of habit and vegetative features encountered in the silversword alliance there are conspicuous but perhaps less spectacular differences in floral features. In Argyroxiphium the heads are large and provided with rays (largest in the Haleakala silversword--as many as 500 florets--and smaller and less attractive in the greenswords). The heads of Wilkesia are relatively large, but are rayless. In all species of Dubautia the heads are rayless and are relatively small, ranging from about 5 florets in D. microcephala Skottsberg to about 50 florets in D. arborea (Gray) Keck. While the heads are yellow in most species, a few have white to pinkish corollas.

The inflorescence types encountered in the silversword alliance include those which are basically racemose, paniculate or corymbose. They are mostly upright but often the individual heads are nutant (nodding) which presumably prevents the accumulation of water that might interfere with the normal pollination mechanism. In the rain forest species D. knudsenii, the entire inflorescence is strongly deflexed so that the individual heads are completely inverted and positioned below the adjacent leaves which provide the flowers with additional shelter from rainwater.

What makes this group especially intriguing to a biosystematist is the notion that all of the forms discussed above have evolved from a single common ancestor over a relatively short period of time (cf. Carr, 1978a). This notion is supported by cytogenetics and the large number of indisputable spontaneous infrageneric and intergeneric hybrids involving markedly different forms within the silversword assemblage (Carr, 1978b and unpublished).

This remarkable situation provided the basis for a successful proposal to the National Science Foundation for a grant to pursue the cytogenetic portion of a study of adaptive radiation in this uniquely Hawaiian group. Additional aspects of the study now in the initial stages of development include a survey of genetic diversity as estimated by iso-enzyme techniques and a survey of phenolic compounds using chromatographic techniques. Plans for the near future also include collaborative work with Dr. Robert Robichaux of the University of California, Berkeley, on the comparative physiological ecology of the silversword alliance.

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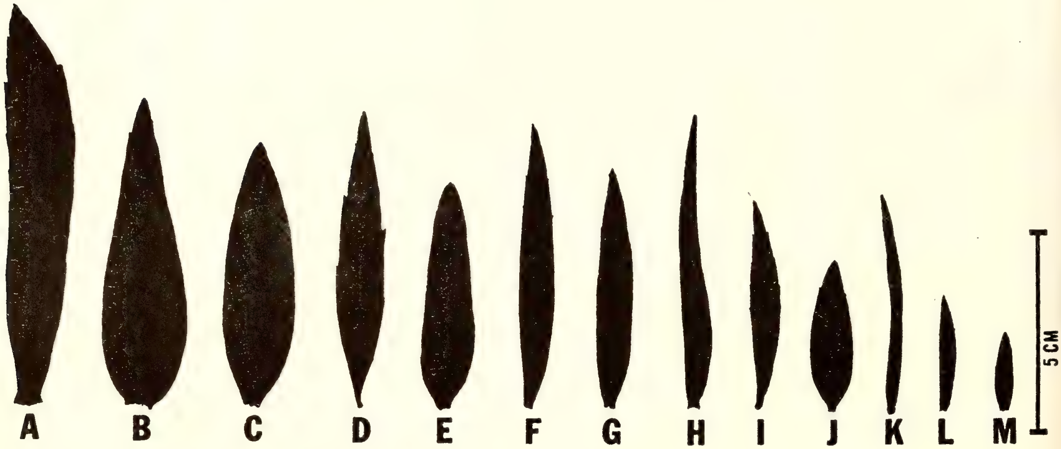

Figure 2. Leaves of Dubautia (subgenus Railliardiaster sensu St. John, 1950) grown under uniform conditions and arranged according to descending surface area. A, D. n. sp.--rain forest; B, D. platyphylla--scrubland ravine; C, D. arborea--scrubland ravine; D, D. sherffiana--dry ridge; E, D. menziesii--dry scrub; F, D. linearis--dry lava flow; G, D. molokaiensis--mesophytic forest; H, D. scabra var. munroi--rain forest; I, D. sp. nov.--dry ridge; J, D. montana--very dry scrub; K, D. scabra var. leiophylla--wet forest; L, D. scabra var. scabra--dry lava flow; M, D. ciliolata--dry lava flow.

RECENT PACIFIC PUBLICATIONS - 4

C.H. Lamoureux and W.J. Hoe,
Department of Botany,
University of Hawaii at Manoa.

ANONYMOUS. 1975. Honolulu Botanic Gardens Inventory 1975. Honolulu: Friends of Foster Garden Press. 195 p.

Provides information on the plants currently growing in each of the 7 areas which form the Honolulu Botanic Gardens system. Families are listed alphabetically within the groups Pteridophyta, Gymnospermae, Dicotyledonae, and Monocotyledonae. Families are those recognized by Airy Shaw in the 8th edition of Willis' Dictionary. Within families, genera and species are arranged alphabetically. For each collection the accession number, place of origin, and location by garden are indicated. An index to families, which is cross-referenced to commonly used family names not recognized by Airy Shaw, is included.

AWASTHI, D. D. 1975. A monograph of the lichen genus Dirinaria. Biblio. Lichenol. Vol. 2. 116 p.

Seven species of the genus are reported from the Hawaiian Islands of which three are new records. They are Dirinaria aegialita (frequently misspelled as aegiliata), D. aspera, D. applanata, D. confluens, D. picta, D. subconfluens, and D. subpicta. The localities given for the Hawaiian collections have been misspelled in most instances (e.g., "Mani, between Kaillia and Keane"), so that the locality is difficult to interpret.

BAKER, K. & S. ALLEN. 1976. Hybrid Hibiscadelphus (Malvaceae) from Hawaii. Phytologia 33:276.

Describes Hibiscadelphus X puakuahiwi Baker & Allen, hybrid novum, based on tree KK-HX-1, growing in Kipuka Ki, Hawaii Volcanoes National Park. This is interpreted as a hybrid between H. giffardianus native to the Kilauea area of Hawaii, and H. hualalaiensis, native to the Kona area of Hawaii but which has been planted in the Kilauea area of the Park.

CARSON, J. L. 1975. Ecological investigations of the soil algae and airborne microflora of the Hawaiian Islands. Ph. D. Dissertation, Univ. North Carolina at Chapel Hill. 166 p.

CLEMENTS, H. L. 1976. Life and the wonders of water. Univ. Hawaii: H. L. Lyon Arboretum Lecture No. 7:1-32.

The unique physico-chemical properties of water are discussed in relation to the role of water in living systems. The functions of transpiration in higher plants are reviewed, and it is concluded that this is an important, beneficial physiological process.

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Comments on the botanical names used by McBride, and a restatement of the authors' opinion that Tacca hawaiiensis is taxonomically distinct from other species of the genus.

DEGENER, O. & I. DEGENER. 1976. Wikstroemia perdita Deg. & Deg., an extinct (?) endemic of a paradise lost by exotic primates. Phytologia 34:28-32.

Describes as new W. perdita from Kalama mauka, Puna, Hawaii from a recently bulldozed tree, and pleads for better protection of rare Hawaiian plants.

DEGENER, O. & I. DEGENER. 1977. Hibiscadelphus Number KK-HX-1, an international treasure in Hawaii. Phytologia 35: 385-396.

Offers the opinion that the Hibiscadelphus growing in Kiupka Ki designated KK-HX-1, which is the type of Hibiscadelphus X puakuahiwi Baker & Allen, is really H. giffardianus and does not represent a hybrid.

DURING, H. J. 1977. A taxonomical revision of the Garovaglioideae (Pterobryaceae, Musci). Bryophytorum Bibliotheca 12:1-244.

The cloud-zone forest inhabiting subfamily Garovaglioideae of the Pterobryaceae is comprised of large, handsome mosses from tropical and subtropical SE Asia, E Australia and the Pacific. Although its major center of distribution is in the Malesian-New Caledonian region (for example, New Guinea with 14 species), a few taxa extend as far as Sri Lanka (two species) and to Kyushu, Hawaii, Rapa Iti and the Marquesas with a single species each.

The first 14 pages of this work are devoted to comments on the morphology of the group; ecology, distribution, and phytogeography occupy a further 8. Taxonomical concepts (13 pages) complete the general part. The revision of the subfamily (pp. 43-221) comprises the bulk of the work. Three genera, Euptychium (7 spp.), Endotrichellopsis (1 species) and Garovaglia (19 species) are accepted. All taxa, including several new, are "keyed", described and illustrated. Of note to Hawaiian botanists: Garovaglia haleakalae Broth., previously known only from a single Haleakala collection, is now considered G. powellii var. haleakalae (Broth.) During, with a distribution also including the Bismark, Solomon, and Caroline Islands.

DE SLOOVER, J.-L. 1978. Herbier Bryologique, Fasc. 7 (nos. 151-175). 5 p. in scheda.

This exsiccata of tropical mosses contains 25 specimens from Moorea: 151-Acroporium lepinei; 152-Brachymenium indicum; 153-Bryum billardieri; 154 & 155-Callicostella papillata; 156-Calomnion schistostegiellum; 157-Calymperes tahitense; 158 & 159-C. tuamotuense; 160-Campylopodium euphorocladum; 161-Campylopus umbellatus; 162-Cyathophorella tahitensis; 163 & 164-Ectropothecium monumentorum; 165 & 166-E. sodale; 167-Fissidens mangarevensis; 168-F. mooreae; 169-Floribundaria aeruginosa; 170-Himanthocladium cyclophyllum; 171-Hypopterygium muelleri; 172-Leucobryum tahitense; 173-Macromitrium incurvifolium; 174-Neckeropsis lepiniana; 175-Orthorrhynchium cylindricum. Nos. 153, 160, 161, 173 and 173 are also represented in the Hawaiian moss flora.

This excellently-prepared fascicle represents the continuation of a series in which both mosses and liverworts from Francophone tropical Africa and the West Indies have been distributed.

EDDY, A. 1977. Sphagnales of Tropical Asia. Bull. Brit. Mus. (Nat. Hist.), Bot. 5(7):357-445.

General historical review, keys, descriptions and illustrations of the Indopacific taxa of Sphagnum. Contains numerous taxonomic and nomenclatural changes. S. vitjianum Schimp. ex Warnst., an element of the

Hawaiian flora, is considered synonymous with the circumtropical *S. perichaetiale* Hampe.

FRAHM, J. P. 1976. Taxonomische Studien zur Gattung *Campylopus* III. Rev. Bryol. Lichenol. 42(4):891-908.

Notes on various species of a troublesome genus. *C. praemorsus* (C. Mull.) Jaeg., an endemic which Bartram (1933. Manual of Hawaiian Mosses) placed into synonymy with the SE Asian-Pacific *C. exasparatus* (Nees & Blume) Brid., is considered a valid species. *C. umbellatus* (Arn.) Par., an Indo-Malesian species reaching Hawaii, is maintained; Dixon's (1922. Journ. Bot. 61) treatment of it as a synonym of *C. richardii* Brid. (Central and South America) is rejected.

FRAHM, J. -P. 1978. Ein Beitrag zur *Campylopus* flora von Hawaii. Rev. Bryol. Lichenol. 44(1):47-52.

Enumeration of recent collections by D. G. Horton & D. H. Vitt (ALTA) from Oahu, Maui and Hawaii. Numerous taxonomic and nomenclatural comments:

C. boswellii (C. Mull.) Par. Unusual costa cross section suggests that this is not a *Campylopus*. Var. *capitulatus* Bartr. is merely a form of the species.

C. exasparatus (Nees & Blume) Brid. is not identical to *C. praemorsus* (C. Mull.) Jaeg.; both taxa are present in Hawaii. *C. exasparatus* is an Indo-Pacific species, while *C. praemorsus* is endemic.

C. hawaiicus (C. Mull.) Frahm comb. nov., is based on the oldest name for the *C.* "densifolius-group." Its type represents what was formerly called *C. purpureo-flavescens* (= *C. densifolius* var. *purpureo-flavescens*). Therefore, *C. densifolius* becomes *C. hawaiicus* var. *densifolius* (Aongstr.) Frahm and *C. hawaiico-flexuosus* (= *C. densifolius* var *hawaiico-flexuosus*) becomes C. *hawaiicus* var. *hawaiico-flexuosus* (C. Mull.) Frahm. Hawaiian material called *C. introflexus* (Hedw.) Brid. is, in fact, Austral *C. polytrichoides* De Not.

Distinctiveness of the Indo-Pacific (incl. Hawaii) *C. umbellatus* (Arn.) Par. from the neotropical *C. richardii* is reaffirmed. The type of *C. pertristis* C. Mull., placed in probable synonymy under *C. umbellatus* by Bartram, is a *Pohlia*. *C. pertristis* is therefore a *nomen dubium* until isotypes (if available) are found.

HATTORI, S. 1976. Notes on some species of the New Caledonian Frullaniaceae (Hepaticae). Bull. National Sci. Mus. B. 2(3): 79-86.

Comments on gynoecia of *Schusterella microscopica*, *Schusterella* subg. Rostratae, *S. chevalieri* is redescribed and illustrated, *Frullania* (Diastaloba) *huerlimannii* sp. nov. (TYPE: Montagne des Sources, Hurlimann 2966, Herb. Hurlimann and NICH), close to the North Borneo *F. meijeri* is described and illustrated.

HATTORI, S. 1976. A remarkable New Caledonian species of *Frullania* Hepaticae). Journ. Jap. Bot. 51(7): 193-198.

F. (Diastaloba) *tixieri* Hattori (TYPE; Mt. Do, MacKee 30-112, NICH) is described and illustrated. Due to peculiarities of perianth morphology, it is placed in the new section Tixiera Hatt.

HATTORI, S. 1976. A new species of *Porella* (Hepaticae) from Hawaii. Misc. Bryol. Lichen. 7(5): 85-87.

Porella hoeana from Haleakala National Park, island of Maui, is described and illustrated. It is compared with Asiatic members of the *P. vernicosa*-complex to which it is most closely related.

HATTORI, S. 1978. Studies on the Asiatic species of the genus *Porella* (Hepaticae). VII. A synopsis of Asiatic Porellaceae. Journ. Hattori Bot. Lab. 44: 91-120.

Keys and annotations to the Porellaceae of southeastern Asia. Of particular interest to Hawaiian botanists: *Porella hawaiensis* Evans (1891. Trans. Conn. Acad. Arts 8: 254) is considered a new synonym of *P. acutifolia* Lehm. & Lindenb., a widely distributed SE Asiatic-Pacific species.

HOE, W. J. 1978. *Riccia sorocarpa* Bisch. in Hawaii. Misc. Bryol. Lichenol. 8(3): 52-53.

Riccia sorocarpa Bisch. is new to the Hawaiian Islands, based upon a collection from Haleakala National Park. Comparison (by means of key) with *R. rechingeri* Steph., the only other *Riccia* species recorded from Hawaii.

HURLIMANN, H. 1976. Hepaticae aus dem Gebiete des sudlichen Pacific IV. Bauhinia 5(4): 191-213.

Continuation of a series of short reports based upon materials collected from New Caledonia, Fiji, Tonga and Tahiti between 1950-1952. This paper on the Aneuraceae cites collections of 24 species of *Riccardia* and 4 of *Aneura* from the islands. *R. baumannii* and *R. hydra*, both from New Caledonia, are new to science; 14 new combinations (mostly transferred from *Aneura*) are proposed.

INOUE, H. 1974-1976. Illustrations of Japanese Hepaticae. Vol. 1 (1974. 190 p. Price: 9000 Yen) and 2 (1976. 193 p. Price: 11,000 Yen). Tokyo: Tsukiji Shokan Publ. Co. Ltd.

Descriptions (mostly in Japanese), distribution maps, photographs as well as critical line drawings and annotations (in English) of 162 species (ca. 1/3) of the Japanese liverwort flora. Species also reported from the Hawaiian Islands include *Calypogeia tosana* (Steph.) Steph. (I: 36-37; 178), *Notoscyphus lutescens* (Lehm.) Mitt. (2: 10-11; 177), *Jubula javanica* Steph. (2: 68-69; 184), *Trocholejeunea sandvicensis* (Gott.) Mizt. (2: 76-77; 185), *Metzgeria conjugata* Lindb. (2: 134-135; 190), *Monoselenium tenerum* Griff. (2: 136-137; 190), *Wiesnerella denudata* (Mitt.) Steph. (2: 150-151; 192). For reviews, see Bryologist 77: 659 and Herzogia 3: 489.

INOUE, H. 1976. Notes on the Plagiochilaceae, V. Studies in the genus *Plagiochila* (Dum.) Dum. in the Hawaiian Islands. Journ. Hattori Bot. Lab. 40: 411-440.

Key, descriptions, illustrations and synonymy for the 13 accepted species (all endemic) of *Plagiochila* in Hawaii, including P. hoei sp. nov.

INOUE, S. & Z. IWATSUKI. 1976. A cytotaxonomic study of the genus *Rhizogonium* Brid. (Musci). Journ. Hattori Bot. Lab. 41: 389-403.

The tropical moss genus *Rhizogonium* contains ca. 30 species in 3 sections: Sect. Rhizogonium (n = 5), Sect. Pleuropelma C. Muell. (n = 7) and Sect. Pyrrhobryum (Mitt.) Mitt. (n = 6, 12). Two Hawaiian species, both in Sect. Pyrrhobryum, are reported: *R. pungens* Sull. (Dioicous: K(n) = 6 = V(H) + V + 2J + v + j(h); first report and *R. spiniforme* (Hedw.) Bruch (Synoicous: K(n) = 12 = 2V(H) + 4v = 4j =2j(h); first

Hawaiian report). Includes brief discussion on sexuality and chromosome numbers; in most moss taxa thus far investigated "monoicous taxa have polyploid chromosome numbers while the closely related dioicous taxa have the basic numbers."

JARAI-KOMLODI, M. 1974. Comparative spore morphological examinations in Funaria and Physcomitrium species. Acta Bot. Acad. Sci. Hung. 20(1-2): 71-81.

Includes photomicrographs of F. hygrometrica Hedw., a cosmopolitan weed known from Oahu and the island of Hawaii.

JARAI-KOMLODI, M., & S. ORBAN. 1975. Spore morphological studies on recent European Encalypta species. Acta Bot. Acad. Sci. Hung. 21(3-4): 305-345.

Includes light and scanning electron micrographs of the following taxon present in Hawaii: E. rhabdocarpa Schwaegr.

MILLER, H. A. 1974. A bryological evaluation of the Polynesian subkingdom. Bull. Soc. Bot. France 121: 287-293.

On bryological evidence, Polynesian subkingdom may be divided into 1) the Hawaiian Region, 2) the Polynesian region, 3) the Fijian Region. The geographically diffuse Polynesian Region may be subdivided into five sections.

Of particular interest to students of Hawaiian botany is his discussion of Hawaiian hepatics. Lists are given for taxa characteristic of an old (relict) flora, genera represented only by endemic species (and presumed to have been established during the mid-Cenozoic), the austral and boreal elements, recent arrivals from the Malaysian region with both endemic and non-endemic species and the more recent arrivals with either a single or all non-endemic species.

MILLER, H. A. 1976. A new Fissidens from Micronesia. Phytologia 34(2): 149-151.

Fissidens duttonii from Babelthuap, Palau, is described and illustrated. In addition to the type, 5 collections are cited. Specimens for illustration (presumably from type) not cited; description indicates that "calyptra not seen" although it is illustrated in Fig. 3.

MSHIGENI, K. E. 1976. Effects of the environment on developmental rates of sporelings of two Hypnea species (Rhodophyta: Gigartinales). Marine Biology 36: 99-103.

Sporelings of H. cervicornis exhibited a higher illuminance optimum, a higher temperature optimum, and a higher salinity tolerance than sporelings of H. chordacea. In all growth experiments on all media tested, H. cervicornis grew faster than H. chordacea. These are useful in explaining the wider natural ecological amplitude of H. cervicornis, and suggest that it is the better choice for commercial cultivation.

NOGUCHI, A. 1976. A taxonomic revision of the family Meteoriaceae of Asia. Journ. Hattori Bot. Lab. 41: 231-357.

Revision of the Asiatic species of the moss family Meteoriaceae, subf. Meteorioideae (the other subf. Pilotrichelloideae is absent from the region). Keys, descriptions, illustrations, etc. Two non-endemic Hawaiian taxa require name changes: Aerobryopsis longissima = A. wallichii (Brid.) Fleisch. and Aerobryopsis scariosa = A. subdivergens (Broth.) Broth. subsp. scariosa (Bartr.) Nog.

PORTER, J. R. 1977. Hawaiian names for vascular plants. College of Tropical Agriculture, Hawaii Agr. Expt. Sta., Univ. of Hawaii, Departmental Paper 1. 64 p.

Reprint of paper first issued in 1972, which is a compilation of recorded Hawaiian names of higher plants. The text is organized alphabetically by family, genus, and species within four groups: ferns and fern allies, conifers, monocots, and dicots. The index is organized alphabetically by Hawaiian name. This printing is identical to the 1972 printing except for the addition of a few references to earlier publications. Single copies are available to Hawaii residents without charge from county agents. Out-of-state inquiries or bulk orders should be sent to College of Tropical Agriculture Order Desk, Room 108 Krauss Mall, 2500 Dole St., Honolulu 96822.

PURSELL, R. A., & W. J. Hoe. 1977. *Fissidens* in Hawaii. Journ. Hattori Bot. Lab. 43: 81-106.

(Authors' abstract). "Eleven species of *Fissidens* are recognized in the Hawaiian bryoflora. *Fissidens hawaiicus* and *F. oahuensis* are considered synonymous with the cosmopolitan *F. bryoides*, both *F. baldwinii* and *F. bishopii* with *F. elegans*, and *F. mauiensis* with *F. pacificus*. *Fissidens taxifolius* is considered an element of the flora. *Fissidens intermedius* is reported in the flora for the first time, while *F. bryoides* and *F. elegans* are reported for the first time as such. A key, descriptions, illustrations and maps indicating local distributions are provided for all species."

In an addendum, the authors confirm the presence of F. aphelotaxifolius as the twelfth species of the genus locally.

RUNDEL, P. W. 1975. Primary succession on granite outcrops in the montane southern Sierra Nevada. Madrono 23(4): 209-220.

(abstracted from author's introduction)---"Much of the ecological literature on primary succession on rock surfaces have implied that primary succession progresses linearly from colonization by cryptogams, through herbaceous and shrub communities to an eventual climax forest community. Recent studies in Hawaii on lava rock, however, have shown that a different progression can occur. *Metrosideros collina* (ohia) is the dominant climax forest species on incipiently weathered lava and is also one of the first colonizers on sterile outcrops. While cryptogamic communities may become established more rapidly, they have little significance in the establishment of *Metrosideros* seedlings within crevices on the lava outcrops.

"Primary succession on granite outcrops in the montane southern Sierra Nevada shows a pattern similar to that described for *Metrosideros* in Hawaii. Climax woody species appear early in the successful development of the outcrops, with little influence of cryptogamic or herbaceous communities. While lichens and bryophytes comprise the earliest colonizers on granite outcrops, succession on these outcrops is primarily a function of physiographic weathering leading to the formation of fracture lines suitable for colonization by woody plants. Although environmental modifications brought about by bryophyte communities may lead to outcrop colonization by vascular plants, this situation is rarely important in the overall succession toward climax communities.

SCHLANGER, S. O. & G. W. Gillett. 1976. A geological perspective of the upland biota of Laysan atoll (Hawaiian Islands). Biol. J. Linn. Soc. 8: 205-216.

Suggests Laysan was an active high volcanic island approximately 15 million years ago, and that during past 250,000 years glacio-eustatic sea level changes have resulted in the island fluctuating between a high limestone island and an atoll. The presence on Laysan of birds, snails, and plants interpreted as belonging to upland and montane lineages is explained by suggesting that Laysan acted as a refugium for this assemblage of organisms which was able to keep pace, through great adaptive flexibility, with the drastic habitat changes imposed by tectonic subsidence, erosion, and Pleistocene fluctuations in sea level.

SCHLJAKOV, R. N. 1975. Notulae systematicae de Hepaticis s. str. (in Russian) Nov. Syst. Plant. Non-Vasc. 12: 307-317.

Jamesoniella subg. Crossogyna Schust. is raised to the generic rank, as Crossogyna (Schust.) Schljak, gen. nov. The Hawaiian endemic C. robusta (Aust.) Schljak. comb. nov. is the type of the Sect. Robustae (Grolle) Schljak. comb. nov.

SCHULTZE-MOTEL, W. 1974. Die bryogeographische Stellung der Samoa-Inseln. Bull. Soc. Bot. France 121: 295-298.

(author summary translated)---The Samoan Islands are, bryologically speaking, in a position intermediate between Melanesia and Polynesia. For example, Cyathophorella tahitensis, previously known from the Society Islands and New Hebrides, has been collected recently from Samoa. The bryological flora of Samoa also has affinities with Australia and New Zealand.

SOHMER, S. H. 1976. Herbstia, a new genus in the Amaranthaceae. Brittonia 28: 448-452.

Description of a new monotypic Brazilian genus, segregated from Chamissoa as Herbstia brasiliana (Moquin) Sohmer. Named for the Hawaiian botanist Derral Herbst.

SRIVASTAVA, S. C. and R. Udar. 1975. Taxonomy of the Indian Metzgeriaceae. A Monographic Study. New Delhi: Today & Tomorrow's Printers and Publishers. as bound reprint from New Botanist 2(1).

Apometzgeria Kuwah. (2 spp.) and Metzgeria Raddi (11 species) for India are described and illustrated. Of interest to students of Hawaiian botany: M. decipiens. Three Hawaiian taxa (M. mauiana, M. molokaiensis, M. conjugata) previously reported from India were not available for study and the records are considered uncertain.

As is all too common for many Indian publications, the quality of paper and typeset leave much to be desired and the 5 photo plates are worthless.

ST. JOHN, H. 1976. A plant collection from Niue Island by Jensen in 1876. Pacific Plant Studies 29. Bot. Mag. Tokyo 89: 235-240.

The first large plant collection from Niue, made by F. Jensen in 1876, was studied at the British Museum of Natural History in London. It included 43 species, including 8 new island records, and 1 new species, Myoporum niueanum St. John, which has not been collected since 1876.

ST. JOHN, H. 1976. Two lectotypes in Charpentiera (Amaranthaceae). Hawaiian Plant Studies 51. Phytologia 35: 132.

Lectotypes are selected for C. obovata forma parvifolia Suesseng. and C. obovata forma grandifolia Suesseng.

ST. JOHN, H. 1976. Miscellaneous taxonomic notes. Hawaiian Plant Studies 58. Phytologia 34: 147-148.

Lectotype designated for Broussaisia arguta forma ternata Forbes ex Skottsb. Transfers Antidesma crenatum to Flacourtiaceae as Xylosma crenatum (St. John) St. John. Names as new Thevetia peruviana forma aurantiaca St. John.

ST. JOHN, H. 1976. Additions to the higher flora of Wake Island. Pacific Plant Studies 30. Phytologia 34: 284.

Records 2 adventive weeds and 10 cultivated ornamentals on the basis of color photos provided by D. Court-Smith of the British Royal Air Force.

ST. JOHN, H. 1976. A new Peperomia (Piperaceae) from Maui. Hawaiian Plant Studies 48. Phytologia 34: 362-364.

Describes P. waihoiana St. John.

ST. JOHN, H. 1976. A new form of Alyxia olivaeformis Gaud. (Apocynaceae). Hawaiian Plant Studies 50. Phytologia 30: 388-389.

Describes A. olivaeformis forma retusa St. John from Hanakapiai, Kauai.

ST. JOHN, H. 1976. A new species of Panicum (Gramineae) from Molokai. Hawaiian Plant Studies 42. Rhodora 78: 542-545.

Describes P. moomomiense St. John from sandy substrates at Moomomi beach and Ilio Point.

VANA, J. 1975. Studien uber die Jungermannioideae (Hepaticae). 9. Jungermannia Subg. Plectocolea und Subg. Solenostoma in Hawaii; Erganzungen und Synopsis der Gattung Jungermannia. Folia Geobot. Phytotax., Praha, 10: 357-382.

Keys for fertile and sterile material, descriptions and illustrations of our three species are presented:

1. J. micrantha (Mitt.) Steph., also reported from Tahiti and Samoa, has the following published Hawaiian synonyms: Plectocolea micrantha Mitt; J. mauii Aust. (= Nardia mauii (Aust.) Evans + Plectocolea mauii (Aust.) Mill); J. baldwinii Steph.; J. newellana Steph.; J. sexplicata Steph.; Plectocolea submicrantha Mill. Known from all major Hawaiian islands except Lanai.
2. J. hawaiica (Mill.) Vana is endemic, and has the following published synonyms: Solenostoma hawaiicum Mill.; Nardia exserta Evans; Solenostoma exserta (Evans) Steph. Known from all major islands except Lanai.
3. J. subulata Evans (treated in Vana. 1973. Folia Geobot. Phytotax., Praha, 8: 403) is also known from the U.S. (Minnesota, Missouri), Europe, India, Sri Lanka, Thailand, Korea and Japan. Known from Oahu (Waianae Mountains) and (?Maui-type collection).

WHITTIER, H. O. 1974. The amphigenous bryoflora of French Polynesia. Bull. Soc. Bot. France 121: 277-286.

Discussion of the biogeographic relationships of the island groups of Southeastern Polynesia with each other and with other major Pacific

Archipelagoes, based upon evidence obtained from the mosses. The flora of SE Polynesia is primarily Indomalayan-Southeast Asian, secondarily Austral, with the American element extremely minor.

WHITTIER, H. O. 1975. A preliminary list of Fijian mosses. Florida Scientist 38(2): 85-106.

Catalogue compiled from the literature of the 306 species and varieties (in 106 genera and 39 families) of Fijian mosses. Includes a useful bibliography.

WHITTIER, H. O. 1976. Mosses of the Society Islands. Gainesville: Univ. Presses of Florida. 410 p., incl. 101 pl. $17.50.

Keys to and descriptions of the 172 moss species of Tahiti and adjacent islands, with illustrations for almost all. The first 38 pages deal briefly with the geology and ecology of the islands, as well as the history of bryological collections. The systematic treatment encompasses 39 families, 88 genera and 172 species. Due, in part at least, to the relationships between Pacific island bryofloras (for example, Hawaii and Southeastern Polynesia share 29 species in common), this book should be most useful to any student of Pacific bryology.

WILCZEK, R. and F. Demaret. 1976. *Bryum flavituber* Wilczek & Demaret, espece nouvelle des Iles Hawaii. Bull. Jard. Bot. Nat. Belg. 46: 407-408.

B.f. [Type: Hoe 3422.0 in Bryophyta Hawaiica Exsiccata Ser. I, Dec. 4: 33 (1975) with Holotype at BR] is based upon sterile material collected at the Honolulu International Airport. It differs from its closest relative *B. tenuisetum* Limpr. (Europe, North America: British Columbia, California, Quebec, Washington) principally in possessing rhizoids smooth or nearly smooth rather than papillose, rhizoidal propagules larger, smooth, yellow to pale brown rather than lemon-yellow with protuberant cells, and median leaf cells shorter.

YAMADA, K. 1975. *Radula* collection made by Dr. H. Inoue in Ceylon. Journ. Jap. Bot. 50(12): 372-378.

Ten species, including *Radula ceylanica* Yamada, sp. nov., are recognized from Ceylon. *R. cordata* Mitt., previously known only from the Hawaiian Islands, is also present.

MINUTES OF THE REGULAR MEETING OF APRIL 3, 1978

The meeting was called to order by President Obata at 7:34 p.m.

About 20 people went on the Ka'ena Point hike on March 12. A tour of Koko Crater Botanic Garden led by Paul Weissich will be held on April 15.

The plant donations last month were well attended and various interesting specimens were presented. The next donation will be held in November. The President requested any and all assistance and contributions to supplement the punch and cookies consumed in the social gathering after the meetings.

The Pacific Tropical Botanic Garden contributed two copies of Rock's "Indigenous Trees of the Hawaiian Islands". The books will be given to the two Science Fair winners.

The Vice-president announced that the June meeting will be held on Tuesday, June 6. The speaker will be Dr. Tabrah who will speak on Polynesian medicine.

There will be an outing to Waimea Arboretum sometime in June.

The Vice-president then announced the speaker of the evening, Dr. Ray Fosberg, who spoke on "Floristic Research in Polynesia and Micronesia".

After the main speaker Dr. Lamoureux gave a short talk and slide presentation on the island of Kaho'olawe.

Winona P. Char, Secretary

MINUTES OF THE REGULAR MEETING OF MAY 1, 1978

The meeting was called to order by the Vice-president, Evangeline Funk, since the President was unable to attend the meeting on time.

The treasurer reported that a check has been sent to the Wau Institute in New Guinea.

Ted Green, a specialist on *Hoya*, showed members of the society a plant of *Hoya imperialis*.

The Vice-president then introduced the speaker for the evening, Dr. Harold St. John, who spoke on the "History of Hawaiian Botany".

After Dr. St. John's lecture, President Obata, who apologized for being late, then reminded the members that the next society meeting would be held on June 6 (Tuesday) in St. John, Rooms 013 and 015. A field trip to Waimea Arboretum is also planned for June 18 (Sunday).

The President then discussed the proposed Environmental Impact Statement and proposed plans for Mokueo Islet and members voted in favor of it.

The meeting then adjourned.

Winona P. Char, Secretary

MINUTES OF THE REGULAR MEETING OF JUNE 6, 1978.

The meeting was called to order by President Obata at 7:35 p.m.. It was announced that all persons attending the Waimea Arboretum field trip should meet in the arboretum parking lot at 9:00 AM.

Our Science Fair judge this year was Dr. Clifford Smith. Two awards were presented.

The society will adjourn for the summer and our next meeting will be held on October 2, 1978.

All contributions to the cookie fund be they monetary or edible are greatly appreciated.

Articles for the Newsletter are wanted. Articles by Dr. Derral Herbst and Dr. H. St. John are up-coming. Dr. St. John will present a list of new island records and new species since his "Checklist of flowering plants in the Hawaiian Islands" was published in 1973.

The "Plant-of-the-month" speaker for the evening was Dr. Derral Herbst, who spoke on Panicum carteri which is restricted to Mokoli'i Island (Chinaman's Hat).

The Vice-president then introduced the speaker for the evening, Dr. Frank Tabrah, who spoke on "Polynesian medicine".

Winona P. Char, Secretary

MINUTES OF THE REGULAR MEETING OF OCTOBER 2, 1978

The first meeting after the summer break was called to order promptly at 7:30 p.m. by President Obata.

Under old business, the following were discussed:

- -articles for the Newsletter are needed.
- -the treasurer reported that the society is solvent but inflation is gaining rapidly.

Under new business, President Obata announced that the nominating committee this year will be composed of Ms. R. Gay, Dr. S. Conant and Mr. N. Balakrishnan. No new safaris (with free lunches!) have materialized as yet. Field trips to the Wahiawa Botanic Garden and Lo'i Kalo are planned for the future.

President Obata reminded members that November is plant donation month.

Dr. William Theobald of Pacific Tropical Botanical Garden asked members of the society for permission to include the society's mailing list in announcements concerning guest speakers of the garden. Permission was granted. Dr. Theobald also announced that trips to Pacific Tropical Tropical Botanical Garden and Limahuli Valley for groups of eight people could be arranged.

Dr. Sheila Conant reminded members that the Audubon Society welcomes all society members to attend their meetings at the Waikiki Aquarium - meetings are held every third Monday of the month.

The "Plant-of-the-month" speaker was Evangeline Funk who spoke on the fiber plants found in the Urticaceae. This report was a preview of her pending M.S. degree thesis.

The lecture for the evening was presented by a group of botanists, Dr. Charles Lamoureux, Ms. Lani Stemmermann, Mr. Rick Warshauer, and Mr. Paul Higashino, who spoke on "The Botany of Pohakuloa". Their report was a summation of an Environmental Impact Statement that they prepared for the U.S. Army. Their work forms the basis of the supporting documentation for the U.S. Fish and Wildlife Service to nominate several plants for endangered status.

Winona P. Char, Secretary

MINUTES OF THE REGULAR MEETING OF NOVEMBER 6, 1978

The meeting was called to order by President Obata at 7:35 p.m.

The nominating committeee presented the following proposal for the Society officers for 1979.

President - Dr. Keith Woolliams
Vice-President - Mr. Nadarajah Balakrishnan
Secretary - Ms. Winona Char
Treasurer - Mr. Lowell Funk
Directors - Dr. Gerald Carr
Mr. John Obata (retiring President)

A motion was made to accept the nomination. The motion was seconded and carried without any objections.

President Obata expressed special thanks to all who contributed to the plant exchange, especially to Messrs. Ray Baker, Oscar Kirsch, and Ted Green for their generous donations.

The Audubon Society invited members to their November 20th meeting at the Waikiki Aquarium.

Mr. Steve Montgomery announced that the State Fish and Game have removed the watering trough that was located near the dryland forest at Kanepu'u on Lana'i. The trough attracted deer in the area which had a negative impact on one of the last remaining dry forests on the island .

President Obata announced that the society may have to increase dues by $1.00; any helpful suggestions on raising funds for the society are welcome.

John Obata presented the plant of the month, Stenogyne kanehoana. This particular species is on the proposed list of Rare and Endangered Plants by the Federal government. It is unusual because unlike most Stenogyne, this species has large flowers about 2 inches long.

President Obata then gave his Presidential Address; "Native Hawaiian Flora - A projection on collecting, propagating and preservation".

Winona P. Char, Secretary

RECENTLY COMPLETED THESES IN BOTANICAL SCIENCES AT UNIVERSITY OF HAWAI'I

MSHIGENI, Keto E., 1974. The biology and ecology of selected Hawaiian species in the Hypneaceae (Gigartinales, Rhodophyta). Ph. D. Thesis. Dr. M. S. Doty, Chairman.

Six species of the Hypneaceae have been found to occur in Hawaii. They are *Hypnea cervicornis* J. Agardh, *H. cordacea* Kuetzing, *H. nidifica* J. Agardh, *H. pannosa* J. Agardh, *H. spinella* (C. Agardh) Kuetzing, and *Hypneocolax stellaris* f. *orientalis* Weber-van Bosse. An illustrated taxonomic key to these species has been completed. *Hypnea cervicornis* and *H. chordacea*, which were studied in detail, produced viable carpospores and tetraspores throughout the year and do not follow any strict rhythmic lunar periodicity. Both types of spores in these species showed the "discal" pattern of germination. The germlings of *Hypnea cervicornis* consistently grew faster than those of *H. chordacea*. Field studies on thallus development from *H. cervicornis* spores showed that the carpospores developed into tetrasporic fronds, and the tetraspores produced gametophytic fronds. Thus the life history of the *Hypnea* species is of the *Polysiphonia* type. Both types of spores developed into adult thalli in three months, hence in commercial *Hypnea* farming from spores, harvestable crops can be obtained within three months. In the studies on carrageenan content it was observed that although all the tested species, i.e., *Hypnea cervicornis*, *H. chordacea* and *H. nidifica*, showed a summer decline in the carrageenan level,the carrageenan content exceeded 25% of the dry weight throughout the study period. In the case of *H. nidifica* yields as high as 45% carrageenan were obtained in March. The studies on the standing crops of these species showed the occurrence of standing crop seasonality. Standing crop values were maximum in November and December. In January through May they showed a rapid decline, reaching minimal values in June and July. In August and September the crops showed a steady increase again. Since the decline of *Hypnea* standing crops coincided with the season with the highest frequency of mid-day "zero" and minus low tides and since mid-day tidal exposure caused considerable *Hypnea* bleaching and killing, and since the season of population re-establishment coincided with the season when the mid-day "zero" and "minus" lowtides were completely non-existent, it was concluded that the observed *Hypnea* standing crop seasonality in Hawaii is largely attributable to the the seasonal changes in tidal behavior. In the studies on the potential crop productivity of *Hypnea cervicornis* in the field, values of 1,700 to 3,400 g/sq. m/yr., wet weight, were obtained.

MYERS, Mansell D. 1974. Mercury as a possible inhibitor in fungal populations along Mauna Loa Strip Road, Island of Hawaii. M. S. Thesis. Dr. S. M. Siegel, Chairman.

Volcanism is a source of environmental mercury on the island of Hawaii. The acidic soils tend to conserve the mercury. Rainfall and temperature are also factors that may influence the amount of mercury present in a soil. Only at one site, the Sulphur Banks area, was an inhibitory level of mercury found. Laboratory work showed that as little as 10^{-6} molar CH_3HgCl or $HgCl_2$ would inhibit growth and spore germination of fungi. CH_3HgCl was more toxic than $HgCl_2$. The percent spore germinations of fungal species from the island of Hawaii and the continental United States were compared. The Hawaiian isolates were more mercury tolerant, indicating that they have built up some tolerance to mercury and that natural selection for the more tolerant species may be in progress.

QUEDADO, Rosario M. 1974. The participation of photosynthesis in floral induction of the long-day plant Anagallis arvensis L. Ph. D. Thesis. Dr. D. J. C. Friend, Chairman.

The effect of intensity of irradiation during a single supplementary light period (SLP) on flowering of the long-day plant Anagallis arvensis was first characterized. The percentage flowering increased from 0-50% over the range of 0 to 1900 microeinstein/sq. m/sec. The participation of photosynthesis was investigated during the single period of high intensity supplementary light required for floral induction. The optimal light intensity (400-700nm) for saturating the floral response was 1900 microeinstein/sq. m/sec as measured by the percentage flowering and mean number of floral buds per plant. The saturating intensity (400-700nm) for photosythetic CO_2 uptake during the same supplementary light period was lower, about 650 microeinstein/sq. m/sec. The floral response of plants photoinduced in CO_2 free air was significantly reduced and glucose relieved this effect. Glucose had no significant effect upon the flowering of plants in atmospheric air at 650 microeinstein/sq. m/sec, and neither glucose nor sucrose substituted for the high light intensity requirement. Increasing the CO_2 concentration to 70 µl/liter during the supplementary light period did not increase flowering. The role of the primary photochemical reactions was studied by inhibiting photosynthesis during the supplementary light period. The floral response of plants treated with ammonium hydroxide, sodium nitrite and DCMU was reduced. The degree of inhibition of the floral response was proportional to the suppression of CO_2 uptake. Ascorbate-DCPIP, ATP, NADPH, glucose or sucrose did not relieve the inhibitory effect of DCMU upon CO_2 uptake and flowering. When given alone, ATP and NADPH had no effect on CO_2 uptake and floral response at 650 microeinstein/sq. m/sec. At 1300 microeinstein/sq. m/sec ATP and NADPH slightly promoted CO_2 uptake, ATP slightly promoted flowering while NADPH had no effect on the floral response. Ascorbate-DCPIP did not affect CO_2 uptake but significantly reduced flowering. It is suggested that a high light intensity SLP is required for floral induction because it supplies photosynthetic products. In addition, flowering may be promoted by the action of an intermediate form of phytochrome produced only at high light intensities.

SANTELICES, Bernabe. 1975. Ecological studies on Hawaiian Gelidiales (Rhodophyta). Ph. D. Thesis. Dr. M. S. Doty, Chairman.

The red algal order Gelidiales comprises over 100 biologically and economically important species. The present study attempts to clarify the taxonomy of the Hawaiian species, to search for patterns of morphological variation in the field, experimentally test the relative importance of some external distributional parameters and initiate the mass culture of some selected species. Three genera, twelve species and seven varieties of Gelidiales are recognized, described and illustrated from Hawaii. They are Gelidiella acerosa, G. adnata, G. machrisiana, and G. myrioclada, Gelidium crinale, G. pluma, G. pusillum, and G. reedia, Pterocladia bulbosa, P. caerulescens, P. calaglossoides and P. capillacea. Seven of the twelve species here reported are records new for the Islands. All the morphological characters measured in field collections of Pterocladia caerulescens are affected by water movement, light intensity, seasonality and vertical distribution. The largest and broadest thalli occur at water movement (DF) values of 40 to 62 and intensities of 60% incident light. Branching confers most of the morphological variability to the thalli, while changing within predictable patterns. Thallus branching is proportional to thallus size only at the optimum water movement and lowest (30%)

incident light. The number of branches increases with increasing light intensity or decreasing water movement and changes seasonally as a result of apical decay after spore shedding. Such previously unevaluated phenomena have resulted in numerous taxonomic problems. The biomass distribution of the three commoner species of Gelidiales on three reefs of Oahu was found to form zones parallel to the shore correlated with the changing values of light intensity and water movement. *Pterocladia caerulescens* was restricted to the nearshore margin of the reef, tolerating intermediate water movement and some 30% to 100% of the incident light. *Gelidiella acerosa* extended between both margins of the reef and while having similar light tolerances had a lower water movement optimum. *Pterocladia capillacea* was restricted, toward the seaward edge of the reefs, to areas with high water movement and much lower incident light. In the field the light tolerance of all species increased in higher water movement. Monthly and bimonthly sampling for 13 months showed that thallus size, asexual reproduction and horizontal distribution of the two species of *Pterocladia* as well as the harvestable standing crop of all three species had a seasonal cycle with a maximum during December and a minimum in May. Seasonal thallus bleaching occurred but the seasons were opposite the above. All the biological cycles recognized correlated significantly with seasonal changes of water temperature and salinity. The seasonal changes in total biomass of non-gelidioid algae on the same reefs did not correlate significantly with any of the environmental parameters measured, although a decrease in biomass in winter correlated with maximum storminess. When the biomass distribution of the 19 more common species was considered, four ecological species groups were recognizable at each locality. Group one correlated positively with light intensity and negatively with water movement while a second group had converse trends. The species in the third group had an irregular pattern of distribution while those in the fourth group had a regular annual cycle but did not correlate with any of the physical parameters measured. Rather they correlated negatively with the biomass distribution of other species of the same genus. The horizontal distribution of most species changed throughout the year retracting or expanding across the reef. Laboratory testing of the seasonal factors on the three species of Gelidiales revealed that light intensity, water movement and water quality significantly affected the relative growth and bleaching of all three. Specific differences in tolerance and growth optima to these factors correlated well with the field distribution of all three species. In the laboratory, water exchange or enrichment could replace the effects of water movement darkening the thallus, raising their light and temperature tolerance limits and accelerating growth to 4% daily in both species of *Pterocladia* and to 2.0% in *Gelidiella acerosa*. The three species of Gelidiales were mass cultured in free floating conditions. Only the two species of *Pterocladia* would grow continuously for up to 55 days and, in doing so, adopted a subglobose habit. The maximum daily growth rate was 2.3% for *Pterocladia caerulescens* at a ratio of 2.3 grams of alga per liter of medium and 1.6% for *P. capillacea* at a ratio of 1.7 grams per liter.

NEWSLETTER,
HAWAIIAN BOTANICAL SOCIETY,
C/O DEPARTMENT OF BOTANY,
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